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NEW YORK AIR BRAKE CATECHISM

THE ONLY COMPLETE

TREATISE ON THE NEW YORK AIR BRAKE AND AIR SIGNALING APPARATUS, GIVING A DETAILED DESCRIPTION OF ALL THE PARTS, THEIR OPERATION, TROUBLES, AND THE METHODS OF LOCATING AND REMEDYING THE SAME. IT INCLUDES AND FULLY DESCRIBES AND ILLUSTRATES THE PLAIN TRIPLE VALVE, QUICK-ACTION TRIPLE VALVE, DUPLEX PUMP, PUMP GOVERNOR, BRAKE VALVES, RETAINING VALVES, FREIGHT EQUIPMENT, SIGNAL VALVE, SIGNAL REDUCING VALVES, AND CAR DISCHARGE VALVE. WITH SPECIAL CHAPTERS ON PISTON TRAVEL, WATER BRAKE FOR BOTH SIMPLE AND COMPOUND ENGINES, MAIN RESERVOIR, SWEENEY COMPRESSOR, TRAIN INSPECTION, TRAIN HANDLING, PIPING, RECORDING GAGES, RULES COVERING GENERAL AIR BRAKE PRACTICE, IMPROVED TESTS, BRAKE LEVERAGE, ETC., ETC., ETC.

BY

ROBERT H. BLACKALL

AUTHOR OF "WESTINGHOUSE AIR BRAKE CATECHISM"

FULLY ILLUSTRATED

NEW YORK

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Dedication.

THIS BOOK IS LOVINGLY DEDICATED TO

MY FATHER AND MOTHER

PREFACE.

The use of the New York Air Brake has created a demand for a book descriptive of the parts of the apparatus employed and an explanation of their operation.

The book has been written with the idea of furnishing information, not only for those who are interested in handling the brake, but for those as well who have to do with the installation and maintenance of it.

Detailed information is contained bearing on the peculiarities, troubles, care and remedies, and a special effort has been made to have the index so arranged that any point may be not only located in a particular chapter, but on a special page, thus making it a book of ready reference in which the information desired may be quickly found. In using the index, points in question may best be found by first locating the piece of apparatus concerning which information is desired; the point at issue may then be readily located under the main heading.

Chapters which contain a large amount of general information on the general subject of brakes, train handling, train inspection, leverage, formulæ, rules, etc., will be found, the object sought being to make the book as complete and interesting as possible to those interested in all branches of railroad service.

A special effort has been made to make the book of value to those in road service who are expected to pass examinations as to their knowledge of the air-brake and its operation.

April, 1904. ROBERT H. BLACKALL.

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New York Air-Brake Catechism.

Previous to the introduction of the automatic brake, the straight-air brake was in use.

With this brake the necessary parts located on each car were a brake cylinder and a train pipe, both being directly connected by a crossover pipe. The train pipe, as now, had flexible hose connections at either end of the car.

On the engine was placed a pump, main reservoir, pump governor, air gage, a three-way cock, and the necessary piping to connect the parts.

The pump compressed air into the main reservoir and this reservoir held the entire amount of air to be used for braking purposes on all the cars.

The straight-air valve or three-way cock controlled the flow of air from the main reservoir to the train pipe, directly connected with the brake cylinders; from the train pipe to the atmosphere, and it also had a lap position in which all parts were blocked.

Increasing the train-pipe pressure applied the brakes; reducing the pressure released them; with the automatic brake, the opposite is true, that is, a reduction of train-pipe pressure applies the brakes and an increase of pressure causes them to release. When there is no air in the train pipe, the straight-air brake

is released; with the automatic the train-pipe pressure is charged to a maximum when the brakes are not in use.

The straight-air brake, owing to the slowness of its operation in long trains, the fact that a burst hose or broken train pipe would render it inoperative, and that severe jars which resulted in long trains owing to the head brakes applying so much ahead of those in the rear, was discarded for the plain automatic brake with which the braking power was stored in a special auxiliary reservoir located on each car.

The Automatic Brake.

Q. Where was the difference in the equipment between the straight-air and automatic brake made?

A. Besides the train pipe and brake cylinder, a plain triple and an auxiliary reservoir were added to the car.

Q. With the cars equipped with the automatic brake, what gain was made over the straight-air brake?

A. (1) The necessary braking power, regardless of the length of the train, was stored in the auxiliary under each car for that car, so that the brakes could be full set very quickly compared to the action of the straight-air brake. (2) If the train broke in two or a hose burst, the triples would automatically apply the brakes, while with the straight-air the brakes could not be applied.

Q. What was the essential feature of the automatic brake?

A. The triple valve known as the *plain triple.*

Q. Where was it located?

A. On the car, at the junction of the train pipe, auxiliary, and brake cylinder.

Q. Did the pump and three-way cock remain on the engine?

A. Yes; this was left for later development.

Plain Triple.

There are two types of New York plain triple valves, one with a graduating spring and one without; one with a poppet and the other with a slide valve graduating valve.

The description following is of the type containing the graduating spring and the poppet type of graduating valve.

Q. Name the different parts of the plain triple (Fig. 1).

A. 8, is the graduating post; 9, the graduating spring; *m* and *n* are feed ports; 5 is the triple piston; 6, the slide valve; 7, is the graduating valve which works inside the slide valve; 12, a piston-packing ring; 18, slide-valve spring; *Y*, the port leading to the auxiliary; *X* leads to brake cylinder; *W* leads to train-pipe pressure.

Q. Of what use are 8 and 9 (Fig. 1)?

A. In applying the brakes, when piston 5 moves out and touches the stem 8, held by the graduating spring 9 (Fig. 2), the piston is stopped, if a gradual reduction is being made on the train pipe, when the piston has drawn the slide valve down far enough to make a port connection between the auxiliary and cylinder.

Q. If a quick reduction is being made on the train pipe, will the spring 9 stop the triple piston?

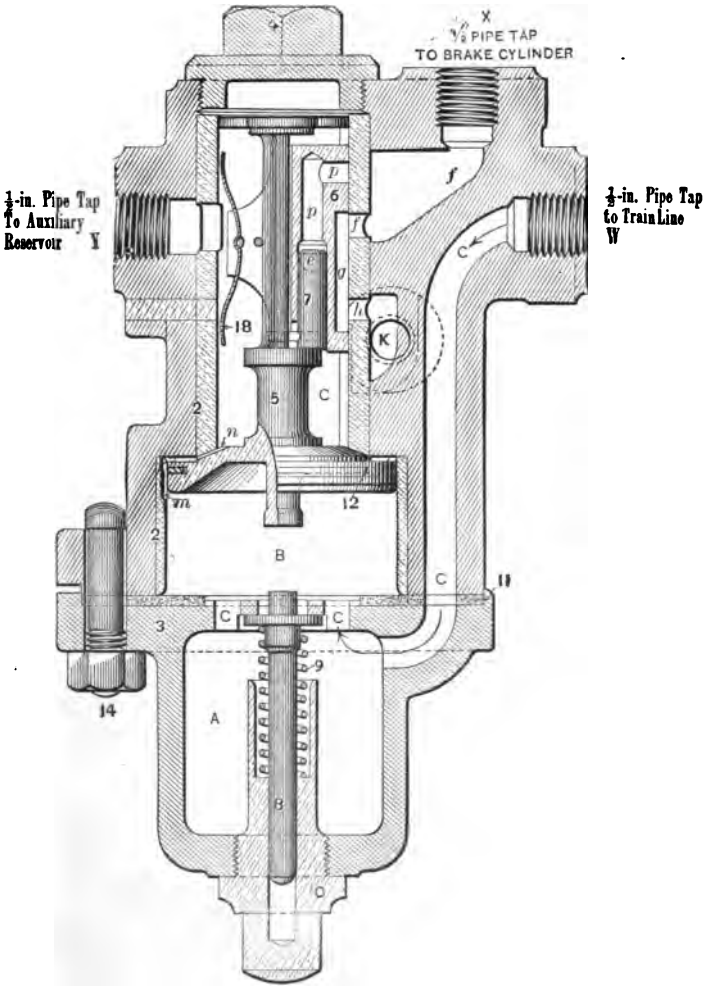


FIG. 1.—NEW STYLE PLAIN TRIPLE VALVE, RELEASE POSITION.

A. No; a quick reduction causes the triple piston 5 to move out quickly, and the sudden impact compresses the spring 9, allowing the piston 5 to move out until it strikes gasket 11, to what is known as emergency position (Fig. 4).

Q. 5 (Fig. 1) is called the triple piston. How is it actuated?

A. Train pipe pressure is on the lower side of the piston and auxiliary pressure on the upper or slide-valve side. It is by changing these pressures that the piston is moved.

Q. What are the duties of the piston as it moves?

A. To open and close the feed ports *m* and *n* (Fig. 1) through which the train-pipe pressure flows into the auxiliary, to move the graduating valve 7 and the slide valve 6.

Q. What is the duty of the graduating valve 7 (Fig. 1)?

A. It is the small valve inside the slide valve, and its duty as it is moved backward and forward by the triple piston is to open and close the port *p* through which, in the service application, auxiliary pressure flows to the brake cylinder.

Q. Does the graduating valve move every time the triple piston moves?

A. Yes, because it is fastened to the stem of the piston by a pin which passes through both the graduating valve and the stem of the triple piston. The pin is represented by the dotted lines running through the lower end of the graduating valve at right angles to it.

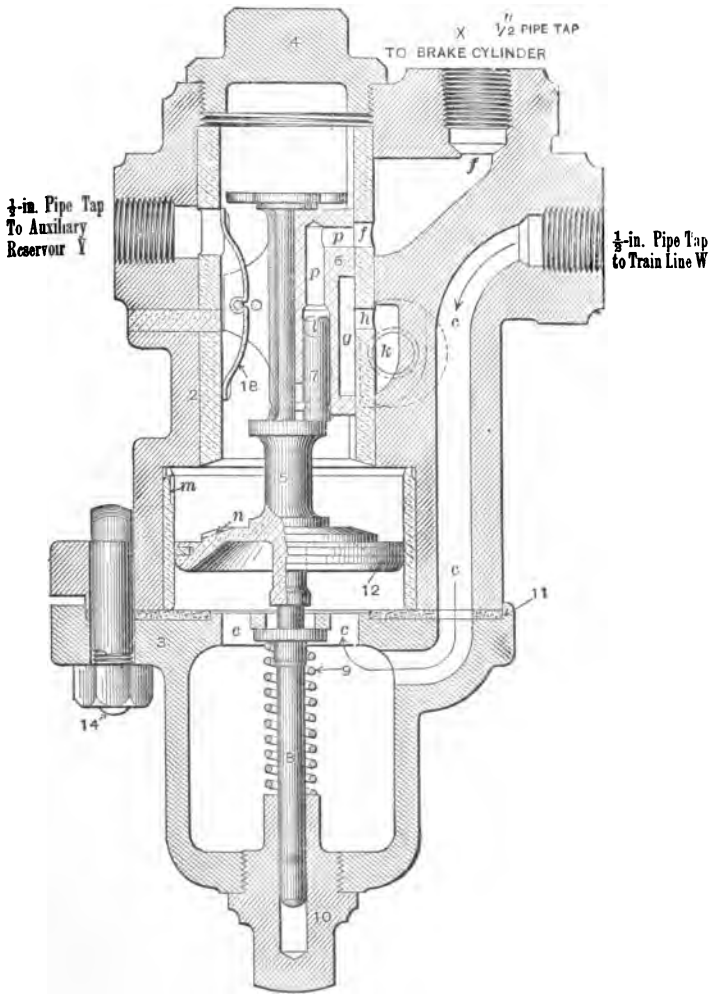


FIG. 2.—NEW STYLE PLAIN TRIPLE VALVE, SERVICE POSITION.

Q. Could we get along without the graduating valve?

A. Yes, but the sensitiveness of the triple would be destroyed.

Q. How does the graduating valve make the triple sensitive?

A. A reduction of train-pipe pressure causes the triple to assume service position, and after the auxiliary pressure has expanded to a trifle below that in the train pipe, piston 5 (Fig. 3) moves back and closes the graduating valve on its seat. Train-pipe pressure had simply to overcome the friction on the triple-piston packing ring to do this, but had we no graduating valve the train-pipe pressure would have had to be strong enough to overcome the additional friction of the slide valve to move it back far enough to close port *p*. When wishing to apply brakes harder, a heavier reduction would be necessary to again move the slide valve to service position. With the graduating valve, the slide valve is moved to service position with the first reduction, where it remains until the brake is released or in case the emergency is used.

Q. What are the duties of the slide valve?

A. In the plain triple, when moved by the triple piston, it serves to make a connection between the auxiliary and the brake cylinder or between the brake cylinder and the atmosphere.

Q. Does the slide valve move every time the piston moves?

A. No; the slide valve will not move when the piston starts down until it has moved far enough for

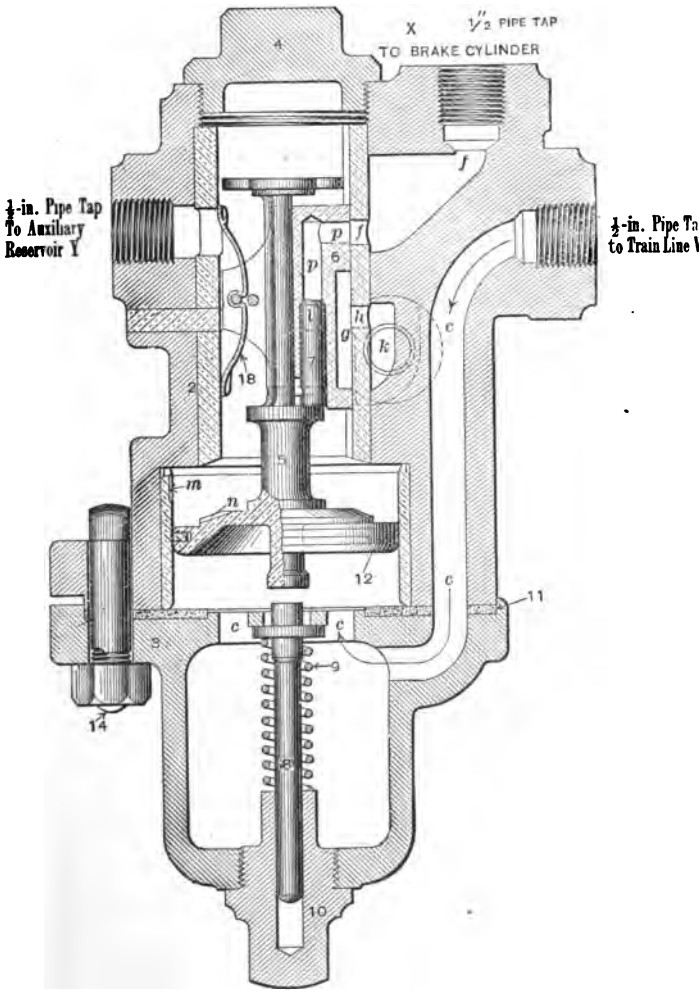


FIG. 3.—NEW STYLE PLAIN TRIPLE VALVE, LAP POSITION.

the lug just above the slide valve to strike the valve. The same, if the piston is down full stroke; when it starts back the slide valve will not move until the piston has gone back far enough to seat the graduating valve.

Q. Of what use is the spring 18 (Fig. 1)?

A. Its duty is to hold the slide valve on its seat and to prevent dirt from collecting there when there is no auxiliary pressure to hold the valve on its seat, as when the car is "dry."

Q. Why is this valve called the triple valve?

A. Because it automatically does three things; charges the auxiliary, applies the brake, and releases it.

Q. If an engine couples to a car that is not charged, how does the triple charge the auxiliary on the car when the hose is coupled and the angle cocks turned so as to allow the compressed air to flow into the train pipe on this car from the engine?

A. A cross-over pipe from the main train pipe couples to the triple at *W* (Fig. 1). The pressure from the train pipe passes into the triple at *W*, through port *c*, as indicated by the arrow, into cavity *B;* thence through the feed ports *m* and *n* into the chamber where the slide valve moves and out into the auxiliary at *Y*.

Q. How long does the air continue to flow into the auxiliary?

A. Just as long as the train-pipe pressure is greater than that in the auxiliary, that is, until the pressures are equal on the two sides of the triple piston 5.

Q. How are the two sides of the piston referred to?

A. The lower side, having train-pipe pressure on it, is called the train-pipe side of the piston, and the upper side, having auxiliary pressure on it, the auxiliary or slide-valve side.

Q. What is necessary to cause piston 5 (Fig. 1) to move from release position?

A. Any reduction of train-pipe pressure; a break in the hose; the use of his valve by the engineer to make a train-pipe reduction.

Q. If a reduction of train-pipe pressure is made, how does the triple respond?

A. Auxiliary pressure now being greater forces the triple piston down.

Q. What two things does the piston do when it starts to move down?

A. It closes the feed grooves *m* and *n* and moves the graduating valve from its seat.

Q. Does the slide valve move as soon as the piston?

A. No, not until the lug on the piston stem is drawn down far enough to rest against the slide valve.

Q. What does the slide valve do as soon as the lug strikes and moves it down?

A. It first closes the exhaust port *g* which in release position connected the brake cylinder with the atmosphere through *X*, *f*, *g*, *h*, and *k*.

Q. How far down does the triple piston travel?

A. Until the projecting stem of the piston strikes the stem 8 held by the graduating spring 9 (Fig. 2).

Q. When these stems touch, how does the slide valve stand?

A. Port *p* of the slide valve is in front of port *f*, and, as the graduating valve was pulled from its seat when the piston first moved, the auxiliary pressure is now free to pass into the slide valve through port *l*, called the service or graduating port, which leads into port *p*. The air passes through port *f*, and out through *X* to the brake cylinder.

Q. How long does the graduating valve remain off its seat so as to allow auxiliary pressure to flow to the brake cylinder?

A. We reduced the train-pipe pressure to allow the greater auxiliary pressure to move the piston down and open the service or graduating port *p* between the auxiliary and cylinder. Just as long as the auxiliary pressure is greater, the piston will stay down and the graduating valve remain unseated. As the auxiliary pressure expands into the brake cylinder it gradually becomes less until, when the train-pipe pressure becomes enough greater than that in the auxiliary to overcome the friction on the packing ring 12 (Fig. 3), the piston automatically moves back and seats the graduating valve.

Q. Does the slide valve move?

A. No, not now.

Q. Why not?

A. The train-pipe pressure was just strong enough to overcome the auxiliary reservoir pressure

and the friction on the packing ring 12, move the piston back, and seat the graduating valve. With the ports all closed the piston would also have to compress the air in the auxiliary to go back any farther. Then, too, the pressure left in the auxiliary acting to force the slide valve on its seat produces a friction, if the valve were moved, that the train-pipe pressure as it stands is not sufficiently strong to overcome.

Q. How do the auxiliary and train-pipe pressures now stand?

A. Practically equal, although the auxiliary pressure had to be a trifle less to allow the triple piston to be moved back sufficiently to seat the graduating valve. The difference in pressure would be so slight that the pressures would quickly equalize through a slight leakage by the triple-piston packing ring.

Q. The brake is now partially applied and the triple is on what is termed lap position; what must be done to apply the brake harder?

A. Another reduction of train-pipe pressure must be made.

Q. How does this set the brake tighter?

A. The auxiliary pressure once more being stronger than that on the train pipe forces the triple piston down until it is again stopped by the graduating post. This movement is just sufficient to unseat the graduating valve, the slide valve remaining where it was with its service port *p* (Fig. 2) in front of the brake cylinder. About the same amount of air pressure passes from the auxiliary to the cylinder as was taken from the train pipe, and the piston

once more having a trifle more pressure on the train pipe than on the auxiliary side moves back sufficiently to seat the graduating valve.

Q. How long can these train-pipe reductions continue to be made and cause the brake to set harder?

A. Until the pressures have finally equalized between the auxiliary and the brake cylinder.

Q. After the auxiliary and brake cylinder pressures were equal, would the brake set any harder if all train-pipe pressure were thrown to the atmosphere?

A. No; when the brakes are full set the auxiliary and brake cylinder pressures are equal, and a further reduction of train-pipe pressure would only be a waste of air that the pump would have to replace in order to release the brakes.

Q. If a further train-pipe reduction were made after the brake was full set, would piston 5 (Fig. 4) move any farther than until the piston and graduating post touched?

A. Yes; the spring 9 could not withstand the greater auxiliary pressure, as it is so much in excess of the reduced train-pipe pressure, and the piston would move down until it seated on gasket 11. In this position there would be a direct connection across the end of the slide valve between the auxiliary and brake cylinder, but the brake would not set any tighter, as the auxiliary and brake-cylinder pressures were already equal.

Q. The brake is now full set. What is necessary to release it?

A. It is necessary to have the pressure on the train-pipe side of the triple piston greater than that on its auxiliary side.

Q. How is this done?

A. By moving the handle of the engineer's valve so as to connect the pressure stored in the large main reservoir on the engine with the train pipe. Air flowing from the main reservoir into the train pipe causes the pressure on the train-pipe side of the triple piston to be sufficiently strong to overcome auxiliary pressure and friction of parts and force the triple piston to release position.

Q. When the triple is forced to release position the slide and graduating valves are carried with it. What two port openings are made in this position?

A. One between the train pipe and auxiliary through the feed ports *m* and *n* (Fig. 1); and one from the brake cylinder to the atmosphere through ports *f, g, h,* and *k*. The triple is in release as shown in Fig. 1.

Q. We notice that the feed grooves m and n (Fig. 1.) are very small. How long would it take to charge an auxiliary from zero to seventy pounds with a constant pressure of seventy pounds on the train pipe?

A. About seventy seconds; and occasionally a little longer.

Q. Will it charge more quickly than this with a greater pressure than seventy pounds on the train pipe?

A. Yes.

Q. Had we a train of fifteen cars, could we charge the fifteen auxiliaries as fast as we could one?

A. No, because we now have fifteen feed grooves in the triples drawing air from the train pipe, and the pump cannot compress air fast enough to keep the train-pipe pressure at seventy pounds.

Q. Why not make these feed grooves larger so as to charge the auxiliaries more quickly?

A. The purpose is to make the grooves sufficiently small that on a long train the auxiliaries will charge in equal time. On a long train there is a tendency for the head auxiliaries to charge faster than the rear ones, and especially if the triple-feed grooves are larger than those now used.

Q. What is likely to happen if some auxiliaries charge faster than others?

A. As the air is fed from the main reservoir back into the train pipe until those pressures are equal, and as the pump will not on a long train supply air as fast as the triple-feed grooves take it from the train pipe, it follows that the auxiliaries which charge the slower will continue to feed from the train pipe and cause a reduction that will set some of the head brakes. The tendency is always for the auxiliaries at the front of the train to charge quicker than those further back.

Q. So far we have spoken only of the action of the plain triple in the service application. What is the difference between the service and the emergency?

A. In service the brakes apply gradually, while in emergency they go on very suddenly.

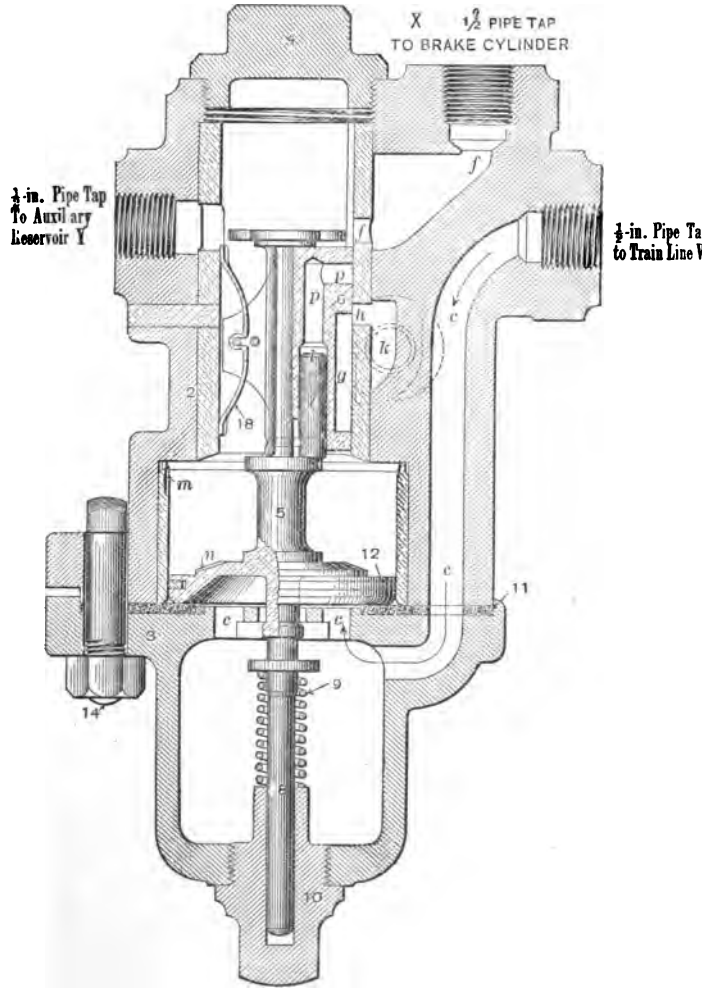


FIG. 4.—NEW STYLE PLAIN TRIPLE VALVE, EMERGENCY POSITION.

Q. A gradual reduction applies the brakes in service. What kind of a reduction is necessary to set the brakes in emergency?

A. A sudden reduction.

Q. Describe the emergency action of the plain triple.

A. The suddenness of the train-pipe reduction causes piston 5 (Fig. 4) to move down suddenly, striking the stem 8 a quick, sharp blow which the graduating spring 9 is not stiff enough to withstand. The piston travels down full stroke and bottoms on gasket 11. This is emergency position, and the slide valve has been drawn down so that air coming through *Y* from the auxiliary passes across the end of the slide valve directly into the large port *f* leading to the brake cylinder without first going through the small service port *p* in the slide valve, as it did in the service position.

Q. Why does the brake set more quickly?

A. Because the air goes direct to the cylinder through a larger port than is used in service.

Q. Do we gain any more pressure with this plain triple in emergency than in full service?

A. No; in both cases the auxiliary pressure equalizes with that in the brake cylinder, but in emergency these pressures equalize more quickly because of the air reaching the brake cylinder through a larger port.

Q. Are plain triples still used?

A. Yes, but they are used almost entirely on engines and tenders.

Plain Triple Valve.

Q. Upon what equipment is the triple valve used which is shown in Figs. 5 and 6?

A. In connection with 6 and 8-inch driver and tender brake cylinders.

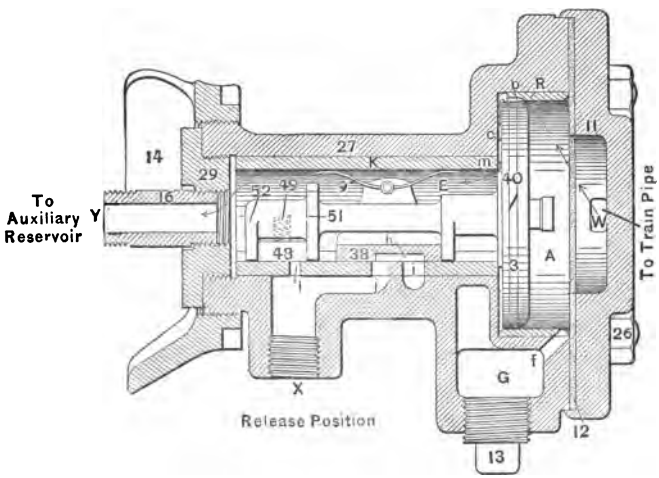


FIG. 5.—PLAIN TRIPLE VALVE.

Q. Name the different parts of this triple valve?

A. 3 is the piston packing ring; 9, the slide-valve spring; 11, the cap; 12, the gasket; 13, the drain plug; 14, the bracket; 16, the nipple; 26, the cap bolts; 27, the triple valve body; 29, the plug; 38, the slide valve, commonly spoken of as the exhaust slide

valve; 40, the triple piston; 48, the graduating valve; and 49, the graduating valve spring..

Q. Explain how this triple valve charges the auxiliary reservoir?

A. Air from the train pipe enters the chamber *A* and forcing it to the position shown in Fig. 5. It then passes through feed port *b* into chamber *E* and thence, as indicated, to the auxiliary reservoir. After a sufficient interval of time has elapsed port *b* will have equalized the train pipe and the auxiliary pressures.

Q. Explain the operation of this triple valve in response to a gradual or service reduction of train-pipe pressure?

A. A description of the operation of this valve under these conditions, aside from the action of the vent-valve piston, would be but a repetition of the description of the operation of the quick-action triple in response to a service reduction. This will be found in the chapter especially devoted to this triple. Fig. 6 shows the position of the parts in a service application.

Q. How does this triple operate in response to a sudden or emergency reduction of train-pipe pressure?

A. A quicker movement of the parts results but the flow of air to the brake cylinder is the same as in a service application (Fig. 6).

Q. All plain triple valves but this one have the service position controlled by a graduating spring, why is one not used with this valve?

A. Because piston 40 cannot move beyond gasket 12 in either a service or an emergency application of the brake, the same valves being used for either application.

Q. If so desired, how can this valve be cut out?

A. By means of a cut-out cock placed in the cross-over pipe extending from the main train pipe to the triple valve.

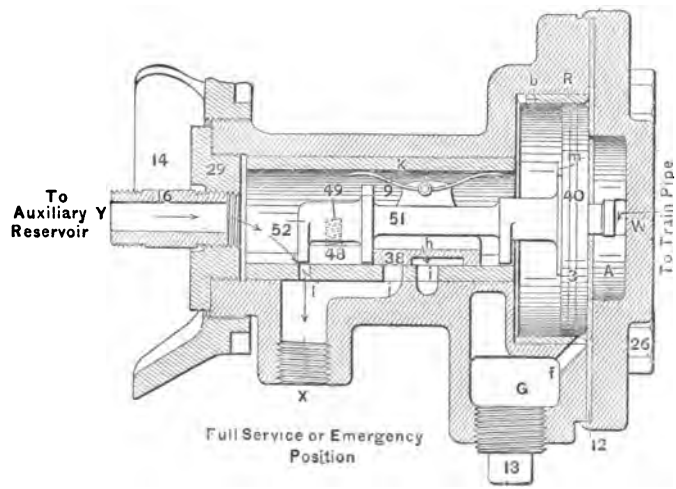


FIG. 6 —PLAIN TRIPLE VALVE.

Q. If the exhaust slide valve leaks how may it be detected?

A. As the cavity of the slide valve is always over the exhaust port there will always be a leak at the exhaust of the triple when the brake is either applied or released if the seat of the slide valve is in poor condition.

Q. How is a leaky graduating valve detected?

A. It only causes a leak at the exhaust port when the triple is in release position. It may leak in service position but the air passing by the valve passes to the brake cylinder where it can not escape since in this position the cavity of the exhaust valve 38 does not register with the port leading to the brake cylinder.

Q. What is likely to happen if the graduating valve leaks?

A. When the triple is in service position this leakage reduces auxiliary pressure and tends to release the brake.

Q. What is the purpose of chamber G?

A. It acts as a drain cup; any accumulation of moisture may be drained by removing the drain plug 13.

Q. What would happen if any accumulation of moisture were not occasionally drained from chamber G?

A. It might freeze in winter and expand into chamber *A*. The expansion, due to freezing, may crack the casting, and any ice in chamber *A* would not permit piston 40 to move sufficiently far to apply the brake; in striking the ice the piston stem would very likely be bent.

Q. Why is it necessary to have the triple valve shown in Fig. 1?

A. This valve is especially designed for use with large cylinders and reservoirs; the ports in it are correspondingly large.

The Quick-action Triple.

Q. Why is the quick-action triple necessary on long trains?

A. The plain triple was satisfactory so long as only the service application is used, but not so with the emergency application on a long train. In this latter case the head brakes would be full set so much sooner than those on the rear, that the slack of the train would run ahead and do great damage.

Q. What two important advantages are gained by the quick-action triple?

A. We are enabled to set the brakes throughout the train more quickly and before the slack has a chance to run ahead and do damage, thus permitting of a quicker stop and a higher safe speed for trains.

Q. In the use of the service application, what is the difference between the results obtained with plain and the quick-action triples?

A. None whatever; their action is practically the same.

Q. Will these two kinds of triples scattered through a train work together properly in service applications?

A. Perfectly.

Q. What does Fig. 7 illustrate?

A. It shows the method of connecting the quick-

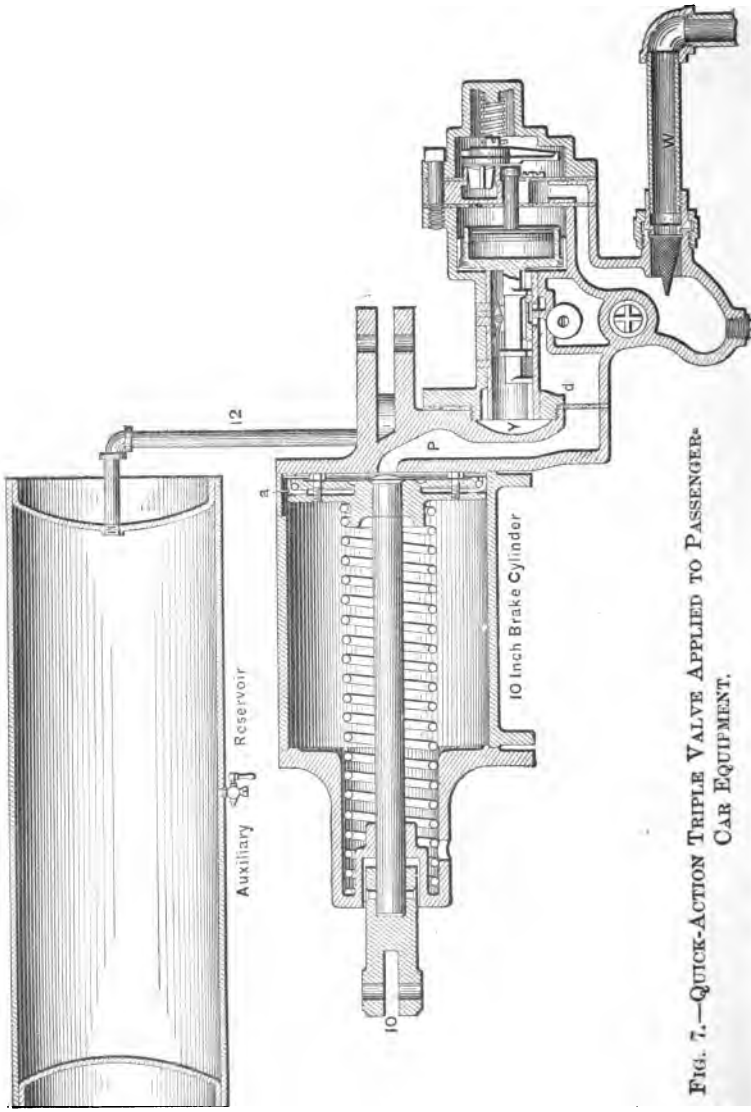


FIG. 7.—QUICK-ACTION TRIPLE VALVE APPLIED TO PASSENGER-CAR EQUIPMENT.

action triple valve, brake cylinder, and auxiliary reservoir in a passenger equipment.

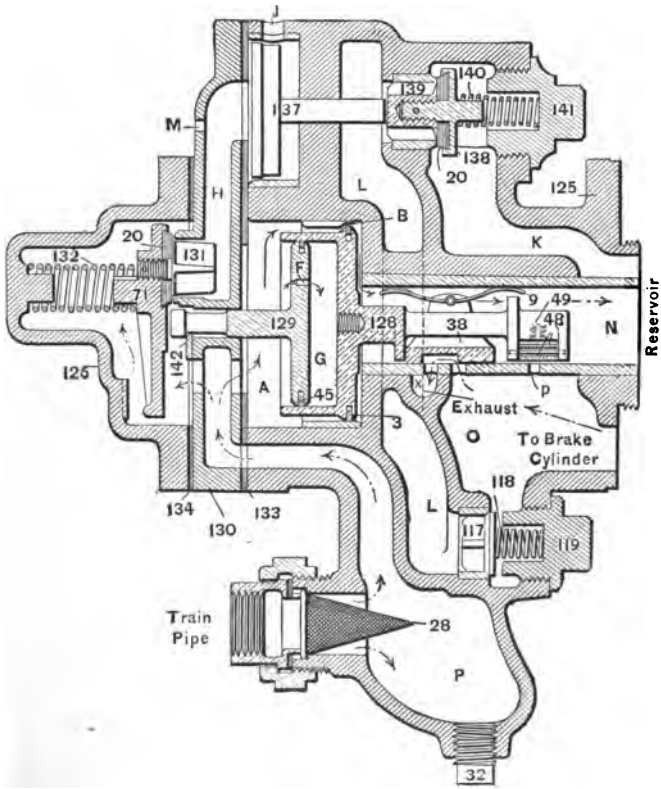


FIG. 8.—RELEASE POSITION.

Q. Name the different parts of the quick-action triple valve (Fig. 8).

A. 3 is the main piston ring; 9, the slide valve spring; 28, the strainer; 32, the drain plug; 38, the

slide valve, frequently spoken of as the exhaust slide valve; 45, the vent valve piston ring; 48, the graduating valve; 49, the graduating valve spring; 71, 131, 20, the vent valve complete; 117, the check valve; 118, the check valve spring; 119, the check valve cap; 125, the triple valve body; 126, the front cap; 128, the main piston; 129, the vent valve piston; 130, the vent valve seat; 132, the vent valve spring; 133, the main cylinder gasket; 134, the front cap gasket; 137, the quick-action valve piston; 138, 139, 20, the quick-action valve complete; 140, the quick-action valve spring; 141, the quick-action valve cap; and 142, the piston stop.

Q. What do Figs. 8, 9, 10, and 11 represent?

A. A diagrammatic representation of the quick-action triple valve in release, service, lap, and emergency positions. They are for explanatory purposes only and serve to give a clearer understanding of the parts and ports, as well as the operation of the triple valve.

Q. What parts of this triple are employed in the service application of the brake?

A. The triple piston 128, exhaust slide valve 38, and the graduating valve 48.

Q. How is the auxiliary reservoir charged?

A. Air enters the triple valve from the train pipe (Fig. 8), as indicated by arrows, passes through the feed port *B*, through the slide-valve chamber and on to the auxiliary reservoir.

Q. Of what use is the small port F (Fig. 8)?

A. To charge chamber *G* with a pressure equal

to that in the train pipe and auxiliary reservoir, and to permit air to escape from this chamber during a service application of the brake, as will be explained in detail hereafter.

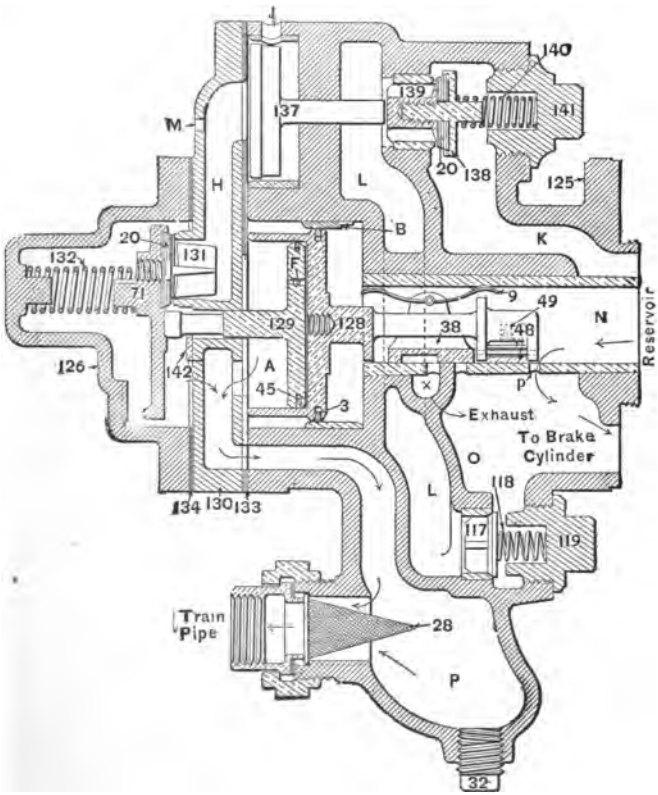


FIG. 9.—SERVICE POSITION.

Q. Of what use is stop 142?

A. To keep piston 129 from moving any farther to the right.

Q. Which in addition to piston 128, graduating valve 48, and slide valve 38 are the parts of the triple used in emergency?

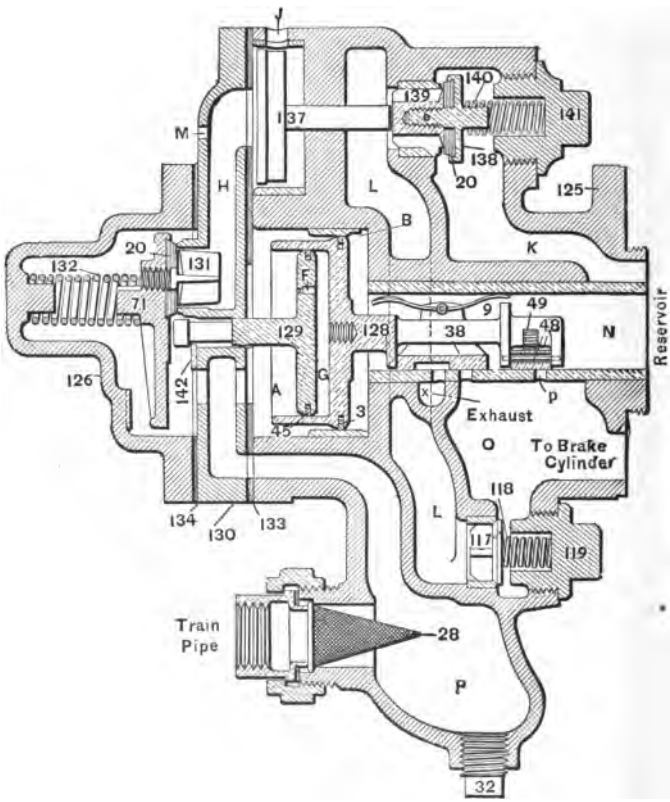


FIG. 10.—LAP POSITION.

A. 129, 71, 132, 131, ports *H* and *M*, 137, port *J*, 139, 138, 140, ports *K* and *L*, and check valve 117 (see Fig. 11).

Q. When a gradual reduction of train-pipe pressure has been made, how is the triple affected?

A. As the train-pipe pressure is slowly reduced

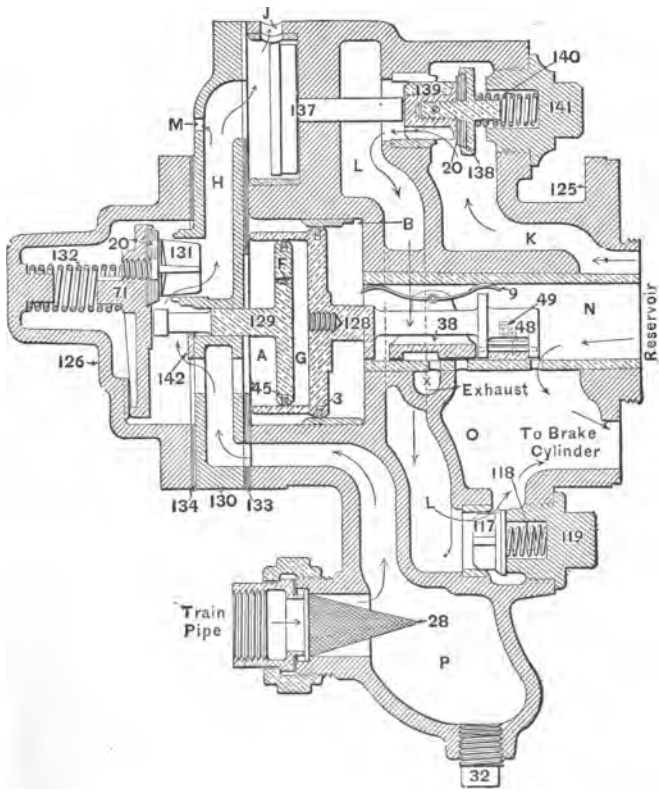


FIG. 11.—EMERGENCY POSITION.

(see Fig. 9), port *F* is sufficiently large to permit the air in chamber *G* to be gradually forced into the train pipe by the greater auxiliary pressure at the

right of piston 128, thus permitting piston 128 to move to the left without disturbing piston 129. As piston 128 moves out it closes the connection between the train pipe and the auxiliary reservoir by moving out past feed port *B*. When the lug on the piston

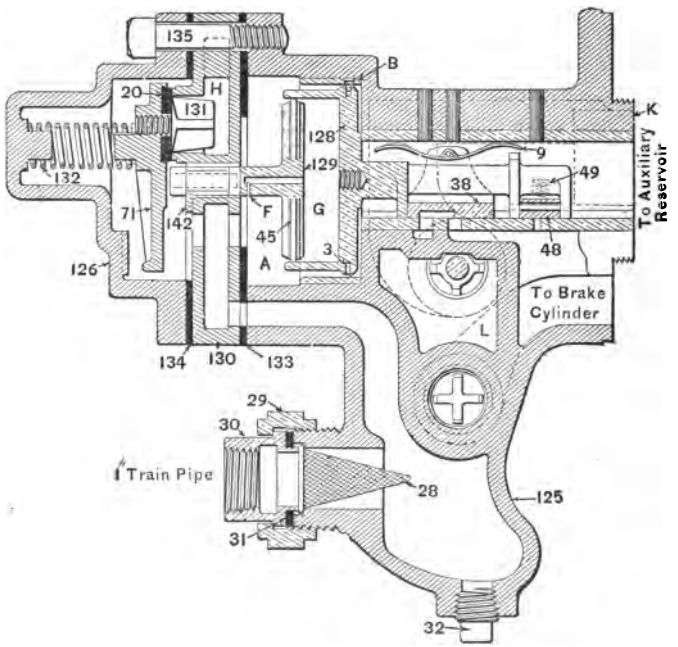


FIG. 12.—SIDE SECTION NEW STYLE QUICK-ACTION TRIPLE VALVE FOR 8 AND 10-INCH CYLINDERS.

stem back of the exhaust slide valve 38 comes in contact with the valve, it is moved ahead, closing the connection between the brake cylinder and the atmosphere. Just after the exhaust is closed the graduating valve has been moved sufficiently to establish a port connection between chambers *N* and *O* by means

of port *p*. The auxiliary reservoir pressure is now free to pass to the brake cylinder and force out the piston; it expands until such time as it is slightly less than that in the train pipe, at which time this pressure forces piston 128 back far enough so that the graduating valve closes port *p* leading to the brake cylinder. The triple is now in lap position (Fig. 10).

Q. Why does the piston stop?

A. Because port *p* being closed, train-pipe pressure, if it forced piston 128 back any farther, would not only have to overcome the additional friction necessary to move the large slide valve 38, but would also have to overcome the auxiliary reservoir pressure; the train-pipe pressure is not sufficiently strong to do this, and the movement of the piston stops as described.

Q. If another train-pipe reduction is made how does the triple respond?

A. The auxiliary reservoir pressure, which is now greater, forces piston 128 out and it in turn draws the graduating valve 48 ahead sufficiently to again expose port *p* leading to the brake cylinder. When auxiliary reservoir pressure expands, and again becomes less than that in the train pipe, piston 128 and graduating valve 48 are again forced back to lap position.

Q. In response to a reduction of train-pipe pressure the exhaust slide valve 38 is moved out where it remains until when?

A. Until it is desired to release the brake.

Q. To release the brake the train-pipe pressure is increased, how does the triple valve respond?

A. The train-pipe pressure, now being sufficiently great to overcome the auxiliary pressure and the friction of the slide valve, forces piston 128 to the extreme right, in which position the exhaust slide valve is as shown in Fig. 8. In this position brake cylinder pressure can, as indicated, escape to the atmosphere through port *x*. Feed port *B* now connects the train pipe and the chamber leading to the auxiliary reservoir; hence this reservoir will be charged to a pressure equal to that in the train pipe. In this position port *F* again recharges chamber *G*.

Q. Explain the effect of a sudden reduction of train-pipe pressure.

A. Air from chamber *G* cannot feed through port *F* quickly and the sudden reduction permits the auxiliary reservoir pressure to force pistons 128 and 129 to the left before the air in chamber *G* has an opportunity to escape (see Fig. 11). The stem of piston 129 forces vent valve 71 from its seat, allowing train-pipe pressure to pass through port *H* and force piston 137 to the right. The stem of piston 137 forces valve 139 from its seat, allowing auxiliary reservoir pressure to pass through the large port *K* and *L*, unseat check valve 117 and pass into the brake cylinder. Port *J* is uncovered when piston 137 is forced to the right and train-pipe pressure passes to the atmosphere through ports *M* and *J*, thus making a sudden reduction of train-pipe pressure which starts the next triple into quick-action, this one starts the succeeding one, and so on throughout the train. Port *p* is also

uncovered and permits reservoir pressure to reach the brake cylinder as in the service application.

Q. What causes piston 137 to again assume its normal position?

A. When the vent valve 71 closes any pressure in front of piston 137 quickly escapes through ports *M* and *J*, at which time spring 140, aided by the auxiliary reservoir pressure in passage *K*, forces piston 137 to the position shown in Fig. 8.

Q. How is the release of the brake accomplished?

A. By increasing the train-pipe pressure the same as after a service application.

Q. If a partial service application of the brake has been made can the emergency feature of the brake be brought into play?

A. No.

Q. Explain the answer to the previous question?

A. The partial service application permits air to be forced from chamber *G* and thus destroys the relative positions of pistons 128 and 129, and the latter cannot, in response to a sudden reduction of train-pipe pressure, be forced over so as to unseat vent valve 71 and thus produce the emergency action.

Q. What do Figs. 12 and 13, 14 and 15 illustrate?

A. They illustrate modifications made in the quick-action triple valve for the purpose of obtaining a quicker equalization between the auxiliary and brake cylinder in an emergency application of the brake. Figs. 12 and 13 show two views of the quick-action triple valve for use with 8-inch freight and 10-inch passenger equipment; Figs. 14 and 15 show two

views of the quick-action triple valve for use with 12 and 14-inch passenger equipment.

Q. Of what do the changes consist in the two triple valves?

A. In both triples the port *F* has been removed from the vent valve piston to the stem of the piston;

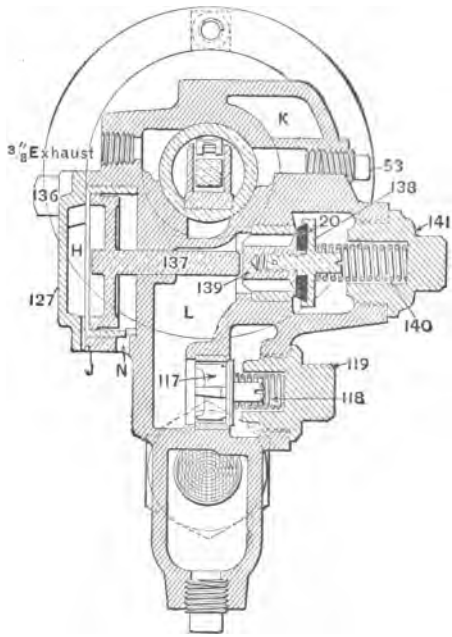


FIG. 13.—END VIEW OF FIG. 12.

in the triple for use with 12 and 14 inch cylinders the graduating valve has been placed on top of the exhaust slide valve instead of following it as in the former triples and in the present standard of quick-action triple valve for 8 and 10 inch cylinders. Port

M has been eliminated, the shape and position of port *J* (Fig. 13) has been changed and port *N* has been added, this latter port being restricted by the shape of the bushing.

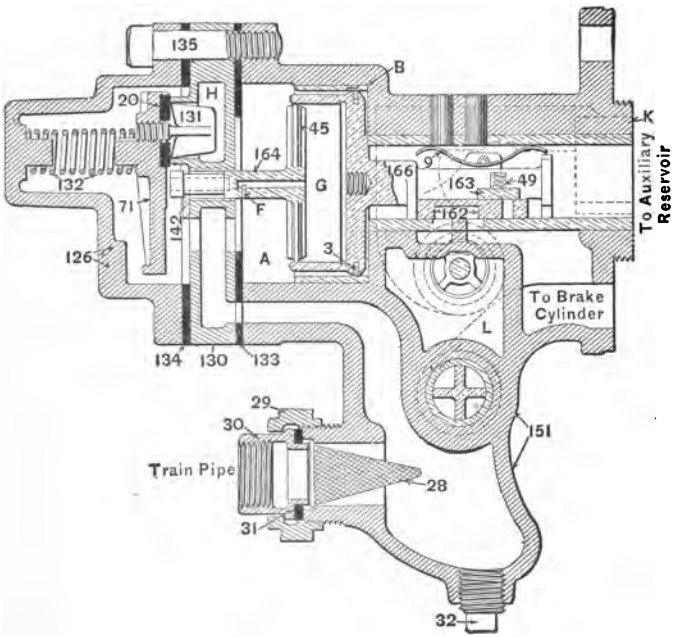


FIG. 14.—NEW STYLE QUICK-ACTION TRIPLE VALVE FOR 12 AND 14-INCH CYLINDERS.

Q. What is the object of changing port F from the piston to the stem?

A. In an emergency application the vent valve piston is forced forward, and as the stem of the vent valve forms a fair fit in the vent valve seat 130 the air from chamber *G* escapes more slowly than formerly, thus tending to hold the vent valve from its seat

longer. This tends to permit more air to reach the emergency piston and this in turn tends to hold valve 138 from its seat longer and permit auxiliary reservoir and brake cylinder pressures to equalize more quickly.

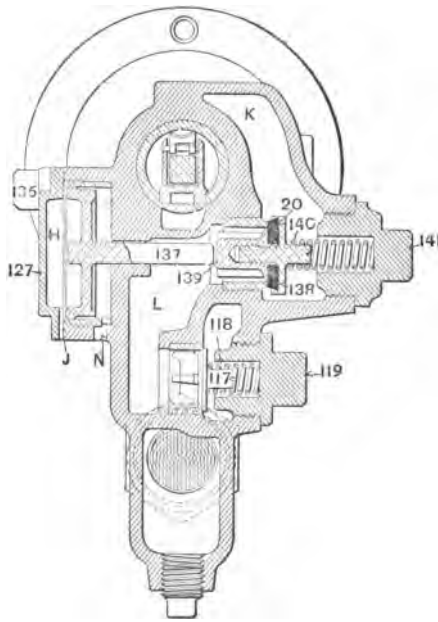


FIG. 15.—END VIEW OF FIG. 14.

Q. What is the idea of placing the graduating valve on top of the exhaust slide valve in the quick-action triple valve for 12 and 14 inch cylinders?

A. To reduce the friction as much as possible. In the other forms of quick-action triple valves it is necessary, during a portion of the stroke, for the piston to have to overcome the frictional resistance of

two slide valves. In the latest special triple valve it is never necessary for the piston to overcome the friction of but one valve at a time.

Q. In a service application of the brake does the triple piston always move out against the gasket 133?

A. This movement may take place, but the travel of the piston depends upon the length of train. When the length of train pipe becomes such that the full service port opening can take air from the auxiliary reservoir faster than the brake valve can take it from the train pipe, the graduating slide valve is only moved sufficiently far to open the service port an amount that will reduce the reservoir pressure as fast as that in the train pipe is being reduced.

Peculiarities, Troubles and Care of the Quick-action Triple Valve.

Q. What could wholly or partially stop the charging of an auxiliary reservoir?

A. The strainer in the train pipe where the cross-over pipe leading to the triple joins the main train pipe, or the strainer 28 in the triple (Fig. 8) being filled with dirt, scale, cinders or oil. The feed port *B* in the triple might be plugged, the triple might be cut out, or there might be a leak in the auxiliary which let the air out as fast as it came in.

Q. If all of the auxiliaries did not charge alike, that is equally fast, what would be the effect?

A. If we wished to apply the brakes very soon, the ones with the auxiliaries not fully charged would not respond to the first reduction of train-pipe pressure.

Q. Will any other trouble result from the strainers being corroded or dirty?

A. Yes; we might not be able to make a sufficiently quick reduction on the triple piston to get quick action.

Q. One triple going into quick action makes a sudden train-pipe reduction, which starts the next triple, and that one the next, and so on throughout the train. If five or six cars together in a train were cut out, had plain triples, or very dirty strainers, would the

triples back of these go into quick-action when the engineer made a sudden reduction?

A. No, on account of the action of friction in the passage of the sudden reduction through the six-car lengths of pipe. The friction gradually destroys the suddenness of the reduction, and there is only a slight and gradual reduction on the train pipe back of the cars cut out.

Q. What bad effect would result in such a case if the engineer did not continue making a reduction?

A. The air coming ahead from the back of the train would kick off the head brakes.

Q. Could these brakes in the rear of the train be applied?

A. Yes; in service but not in emergency.

Q. Water sometimes collects in cavity P of the triple. Where does it come from?

A. It works back from the pump.

Q. What bad effect will water have at this point?

A. It is likely to freeze in winter and block the flow of air through the triple.

Q. What should be done in such a case?

A. Apply burning waste and, when thawed, remove the drain plug 32 to remove the water, or the trouble will recur.

Q. If one triple goes into quick-action, will the rest go?

A. Yes; as a sudden reduction is made on the train pipe through the emergency parts of the triple in this case. This sudden reduction starts the next,

and that the next, and so on throughout the train. This would not be true, however, on the cars where the triple pistons had reached service position.

Q. What is the probable trouble with a brake which, when set in service, will sometimes remain set and sometimes release?

A. A dirty slide valve or graduating valve, which sometimes seats properly and at others not; in the latter case auxiliary pressure escapes to the brake cylinder and allows train-pipe pressure to force this triple to release position.

Q. How may this defect be remedied?

A. Remove the triple piston and attached parts, clean carefully, loosen the packing ring without removing, and rub a little oil on the slide valve bush and ring with the finger.

Q. Why not pour on the oil?

A. Too much oil is bad, as it collects dust, which with the oil forms gum. This causes the triple to stick.

Q. What effect will a leak in the train pipe have if the brakes are not set?

A. It will simply cause the pump to work harder to supply it.

Q. What effect would the leak have if the brakes were set?

A. It would cause them to apply harder.

Q. Will the leak on the train pipe on a car cause only the brake on this car to apply harder, or will it affect all the brakes?

A. All, as the train pipe is continuous throughout the train.

Q. What effect will a leak in an auxiliary have if the brakes are released?

A. It will keep the pump at work the same as a train-pipe leak.

Q. What effect would this leak have if the brakes were applied?

A. It will leak the brake off on the car where the leak is, and then, drawing air from the train pipe through the feed ports, it will gradually apply the other brakes harder.

Q. What would cause a constant blow from the exhaust port?

A. A leaky slide valve 38.

Q. What would cause a constant blow through port M or J?

A. A leak on the seat of valve 139 or 131, or check valve 117, if the brakes were applied. The first defect would probably cause a blow at port *J* and the latter ones at *M*.

Q. Could a leak past valve 139, Fig. 8, cause a blow at other than ports J and M?

A. Yes; if a bad leak existed, the pressure could lift check 117, pass to the brake cylinder, and thence to the atmosphere if the triple valve were in release position.

Q. What will be the effect of a leaky graduating valve?

A. This will tend to cause a leak at the exhaust

port when the triple valve is in release position, and to release the brake when applied.

Q. Why does the blow not continue after the brake is applied?

A. Because the exhaust port is closed when the triple piston moves to service position.

Q. Why will leakage by this valve tend to release the brake?

A. Because it reduces the auxiliary reservoir pressure to the still lower brake-cylinder pressure, thus permitting the greater train-pipe pressure to force the triple piston to release position.

Q. Will a graduating valve that leaks always release a brake?

A. No; this depends upon how much leakage there is, and upon the condition of the packing ring in the triple piston. If this ring leaks sufficiently to permit air to feed from the train pipe to the reservoir as fast as it is leaking from the reservoir, the leakage by the graduating valve will have no other effect than to gradually take air from the train pipe, tending to apply the other brakes harder.

Q. What trouble would result if port F became corroded so that the pressure in chamber G could not feed into the train pipe as fast as a gradual reduction of train-pipe pressure was being made?

A. Piston 129 would be forced out as in emergency, and throw the whole train into quick action.

Q. What effect would result if check valve 117 leaked?

A. When the brakes were applied either in service

or emergency, air from the brake cylinder would feed by the check valve into port *L*, by the stem of piston 137 and to the atmosphere through port *J*. The leakage would tend to gradually release the brake on this particular car the same as if the packing leather leaked in the brake cylinder.

Q. Will braking power be lost if train-pipe reductions are continued after the brakes are full set?

A. It is likely to be lost very slowly, on cars that have been in service for some time, and which have not been well maintained.

Q. Explain this last answer.

A. When the train-pipe reduction has been continued after the reservoir and cylinder pressures have become equalized, the auxiliary and brake cylinder pressures will be directly connected, and any air that can leak by piston 128 into the train pipe represents so much of a loss in braking power. If valve 117 or 139 leaked under these conditions, there would be an additional loss of braking power due to back leakage.

Q. What effect would be noticed if valve 139 leaked?

A. There would be a constant escape of air at port *J*, which would keep the pump working when the brakes were not applied. When they were applied, the leakage of auxiliary pressure would release the brake on this car. When this brake released, the feed groove would supply the leak, thus causing a train-pipe reduction, which would help to creep the other brakes on harder.

Q. Does this triple apply the brakes any harder in emergency than in the service application?

A. No; the brake is not applied any harder, but it is applied more quickly, owing to the use of two sets of ports, the one controlled by the emergency parts being comparatively large, thus permitting of a quick passage of air from the auxiliary to the brake cylinder. With this triple valve train-pipe pressure is vented to the atmosphere in emergency instead of to the brake cylinder.

Q. What is most often responsible for the emergency application of the brake in response to a gradual or service reduction of train-pipe pressure?

A. A dirty triple valve; one which sticks and operates in jumps.

Q. Are passenger and freight triple valves the same?

A. No; the ports correspond with the size of brake cylinder with which they are to be used.

Q. How may the two triples be distinguished from each other?

A. A letter *P* is cast on the passenger triple valve.

Q. After an emergency application of the brakes, why is it that occasionally one of the brakes will stick, and tend to stick all of the other brakes, when an attempt is made to release?

A. This is caused by the vent valve sticking open, thus causing the air to be taken from the train-pipe faster than it can be supplied.

Q. What should be done in such a case?

A. Locate the faulty triple by the blow at the vent port, and, if jarring will not cause the blow to cease, the brake on this car should be cut out.

Engineers' Brake Valves.

In the description of the two latest types of brake valves all views are not repeated where the corresponding views are alike, as are the horizontal outside views of the valves (Figs. 16, 17, and 19) and the supplementary reservoir, Fig. 23.

The chief changes in the 1902 valve, as compared with the previous valve, consist in the addition of the ball-check valve 183 (Fig. 29), the vent valve 180, the addition of port *O* (Figs. 27 and 29), also of cavity *P* (Fig. 25) in the slide valve, and a modification in the shape of ports *T*.

The views of the 1902 model brake valve showing release, running, lap, beginning of service, service graduation, and emergency positions also illustrate the corresponding position of the parts in the earlier valve.

Q. Name the different positions of the brake valve and explain their uses.

A. Release position is the extreme position of handle 123 to the right (Fig. 29). This position is used to release brakes and to obtain a quick recharge; if the brake-valve handle is left in this position, the train pipe and the auxiliary reservoirs will be charged with a pressure equal to that carried in the main reservoir.

Running position is the next one to the left, the position of the handle as shown in Fig. 30. This is the position used when the brakes are inoperative, as

when the engine is using steam. In this position an excess pressure of 20 pounds will be carried in the main reservoir.

Lap position is the next one toward emergency position (Fig. 31). In this position all ports are blanked

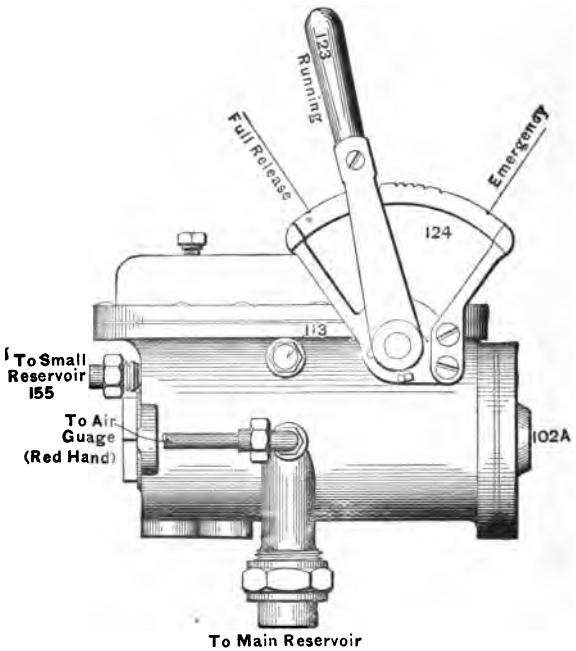


FIG. 16.—RUNNING POSITION

except port *O*, which is open through cavity *P* to the atmosphere.

The service graduating positions are the five notches as indicated in Figs. 17 and 32. With the brake-valve handle in any of these notches a gradual

or service reduction of train-pipe pressure will be made.

With trains of five cars or less the first service notch is used for the first reduction; to obtain heavier reduction the handle is moved to the successive

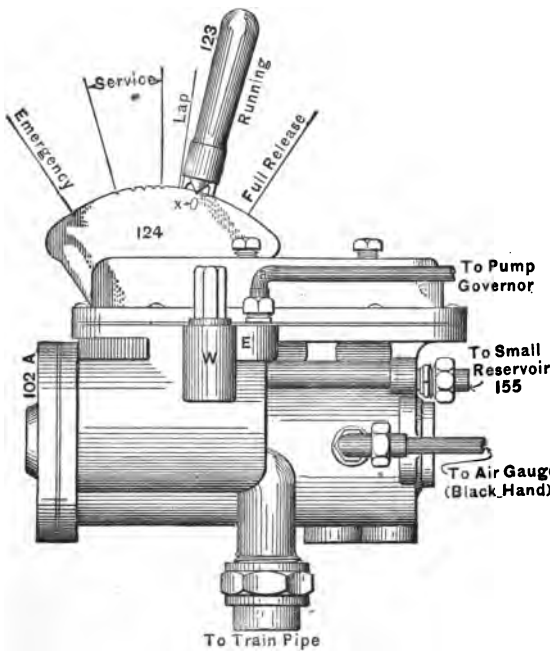


FIG. 17.—RUNNING POSITION.

notches. With longer trains the second notch should be used for the initial reduction.

The emergency position is that at the extreme left (Fig. 34). This position is used when it is desired to obtain a sudden application of the brakes, as in an actual case of danger.

Q. Name the different parts of the older form of valve (Figs. 18 and 20).

A. 90 is the feed valve spring; 96, oil plugs; 97, feed or excess pressure valve; 101*A*, valve body;

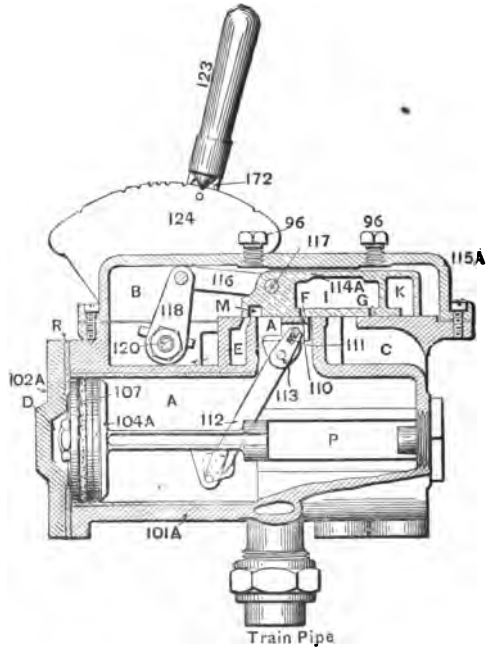


FIG. 18.—RUNNING POSITION.

102*A*, back cap; 104*A*, equalizing piston; 110, graduating valve; 111, graduating valve spring; 112, graduating valve lever; 113, fulcrum pin; 114*A*, main slide valve; 115*A*, valve cover; 116, connecting links; 117, link pins; 118, slide-valve lever; 120, lever shaft; 121 (Fig. 20), lever shaft packing; 123, valve handle;

124, quadrant; 155 (Fig. 23), supplementary reservoir, and 172, the quadrant latch.

Q. What pressure is in chamber A on the right of piston 104A (Fig. 18)?

A. Train-pipe pressure.

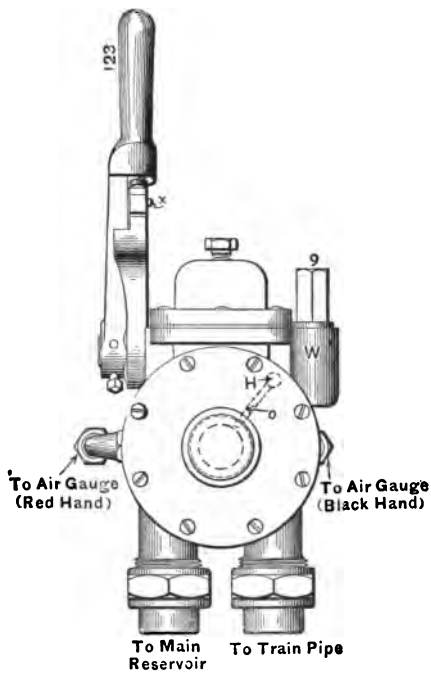


FIG. 19.—END VIEW.

Q. What pressure is on the left of piston 104A?

A. Chamber *D* pressure. It is connected with the supplementary reservoir, Fig. 23.

Q. What pressure is in chamber B?

A. Main reservoir pressure.

Q. How is the graduating valve 110 operated, and of what use is it?

A. The valve is controlled by lever 112, fulcrum

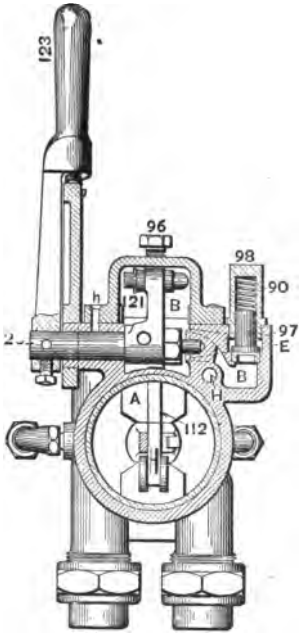


FIG. 20.—END SECTION.

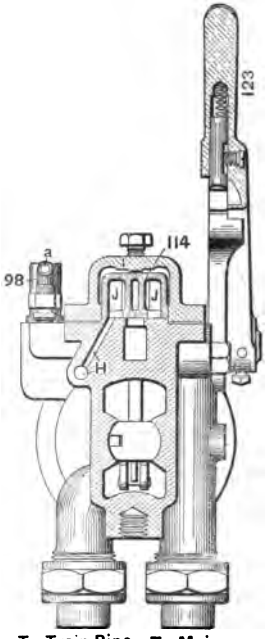


FIG. 21.—END SECTION.

at 113. The movement of lever 112, fastened to the stem of the piston 104*A*, is controlled by the movement of the piston. It stops the escape of train-pipe pressure at the proper time during a service application.

Q. How is piston 104A actuated?

A. Its movement is the result of the change of pressures on either side of it; that on the right is train-pipe pressure, and that at the left is supplementary reservoir pressure (Fig. 23).

Q. Of what use is port H in the valve seat (Fig. 21)?

A. It connects with another port *H* which runs the length of the body (Fig. 24). One end of the port is connected with the supplementary reservoir (Fig. 23), and the other at the left of piston 104*A*.

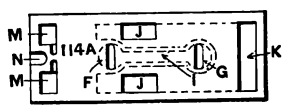


FIG. 22. – FACE OF SLIDE VALVE.

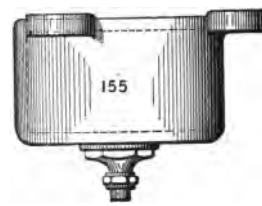


FIG. 23.—SUPPLEMENTARY RESERVOIR.

Q. In what position is the valve as shown in Figs. 18 and 30?

A. Running position.

Q. Explain running position.

A. In this position the ports *F*, *G*, and *K* are closed and we have a communication between the main reservoir and train pipe. Air feeds into the valve from the main reservoir (Fig. 16) into cavity *B* (Figs. 18 and 20). When the pressure in the main reservoir is enough greater than that in the train pipe to compress spring 90 (Fig. 20), the valve 97 is forced from its seat and air passes into chamber *E*.

Looking at *E* in Fig. 18, we see that the air is free to pass into port *M* and down into the train pipe or

chamber *A*. Valve 97 and spring 90 give us our excess pressure in this position. Port *J* (Figs. 21 and 22) is so placed in the slide valve that in running position it is directly over chamber *A* and port *H*. We thus have both sides of piston 104*A* connected.

Q. Explain lap position.

A. Lap is the position beyond running toward emergency (Fig. 31). The slide valve is moved sufficiently to close the communication between the main reservoir and train pipe by shutting off port *M* from

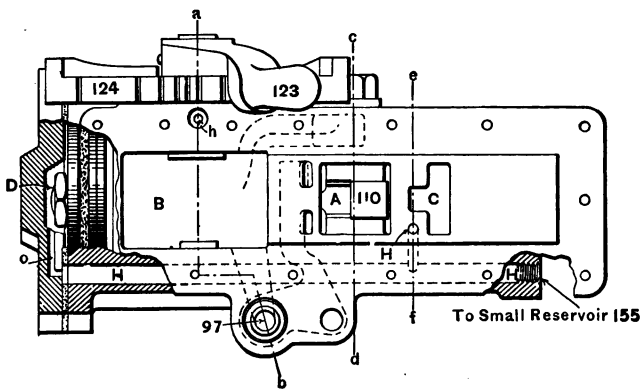


FIG. 21.—TOP SECTION.

chamber *A*; but, as described in running position, chamber *A* and the supplementary reservoir are connected through port *J*.

Q. Explain service position.

A. The valve is in service position when the latch is in one of the graduating notches marked service (Fig. 17), and the parts are shown in service position in Fig. 32. Before reaching this position the connec-

tion between chambers *A* and *D* through ports *J* and *H* was closed. In service position the slide valve 114*A* is moved far enough to the right so that port *F* (Fig. 22) is over chamber *A*. Train-pipe pressure passes from chamber *A* through port *F* and the cavity of the slide valve 114*A*, thence through port *G*, which is now over port *C*, and out to the atmosphere (Fig. 32).

No air has been taken from chamber *D*, and when the train-pipe pressure in chamber *A* has been reduced so that the pressure in chamber *D* is sufficiently

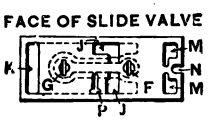


FIG. 25.

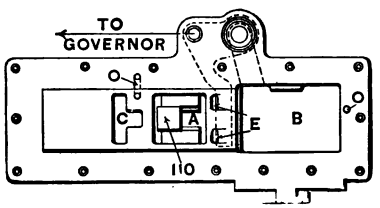


FIG. 26. SLIDE VALVE SEAT.

strong, it forces piston 104*A* to the right until the top of lever 112 has moved the graduating valve 110 far enough to the left to close port *F*. By the time the graduating valve has closed port *F* (Fig. 33), the pressure in chamber *D* has expanded sufficiently to make it equal with that in the train pipe or chamber *A*. When the valve latch has been placed in one of the graduating notches it should be left there until another reduction is desired, when it is again moved toward emergency position according to the reduction desired.

Q. If, on account of a temporary derangement, the graduating valve will not cut off when placed in a service notch, what should be done?

A. When the desired amount of train-pipe reduction has been obtained, the brake-valve handle should be moved toward lap position until the discharge of air ceases.

Q. Which service notch is used when making the first reduction?

A. With five cars or less it is customary to use the first notch; on a longer train, or on a heavily-

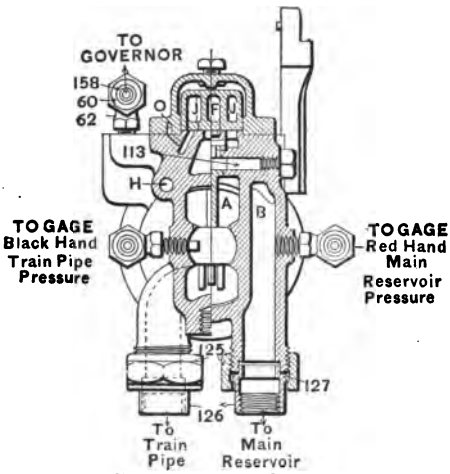


FIG. 27.—END SECTION.

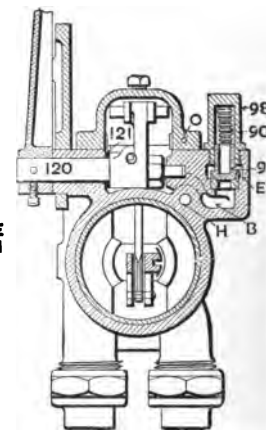


FIG. 28.—END SECTION.

loaded freight train, the second notch may be used, and the valve handle is placed in the other service notches according to the amount of braking power desired.

Q. Explain emergency position.

A. In emergency position the slide valve has been moved to the extreme left, and the parts of the valve are in the position shown in Fig. 34. With the valve

in this position, air passes from chamber *A* through the large ports *J*, *K* (Figs. 22 and 34), and through

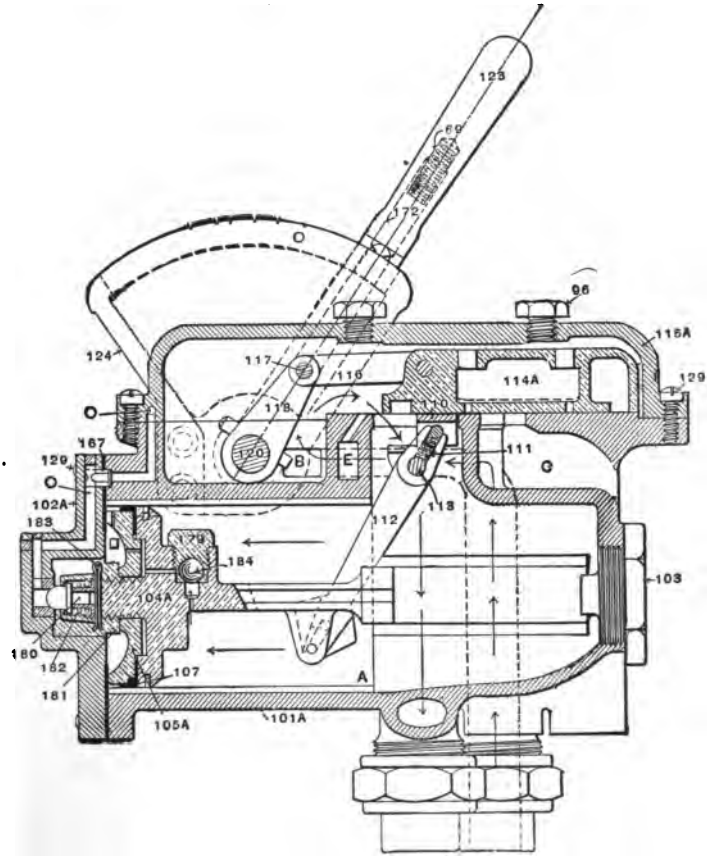


FIG. 29.—RELEASE POSITION.

port *C* to the atmosphere, thus making a sudden reduction that causes the triple valves to respond in quick-action.

Q. Explain quick-release position.

A. When the handle is moved to quick-release position (Fig. 29), the slide valve 114*A* (Fig. 22) is

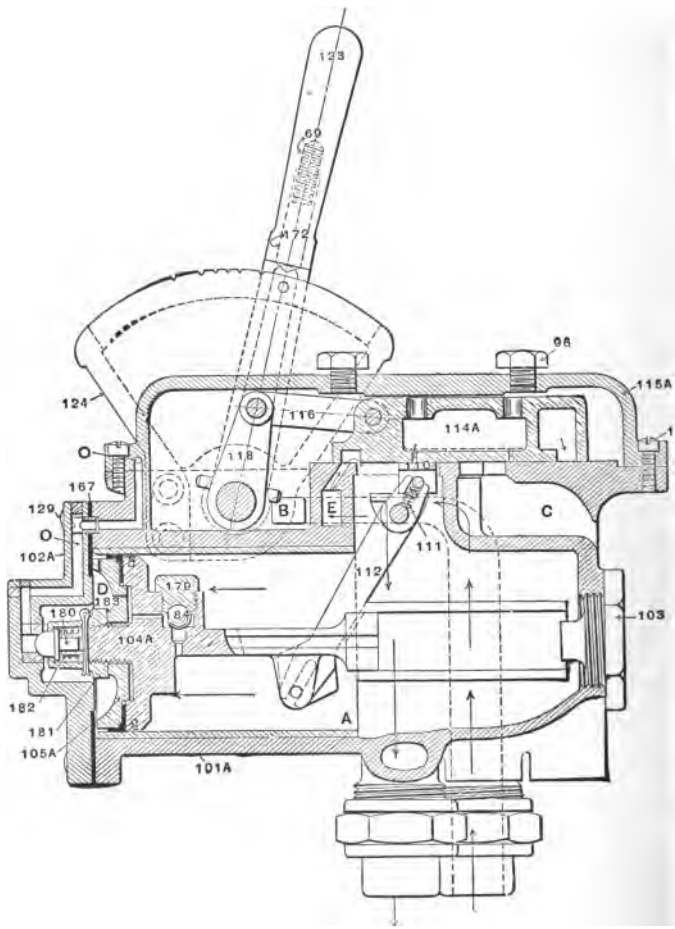


FIG. 30.—RUNNING POSITION.

carried to the extreme right and air passes direct from cavity *B* (main reservoir pressure) by the end of the slide valve into chamber *A*, or train-pipe pressure, also into chamber *E* and thence to the governor. In this position air in chamber *D* passes through ports

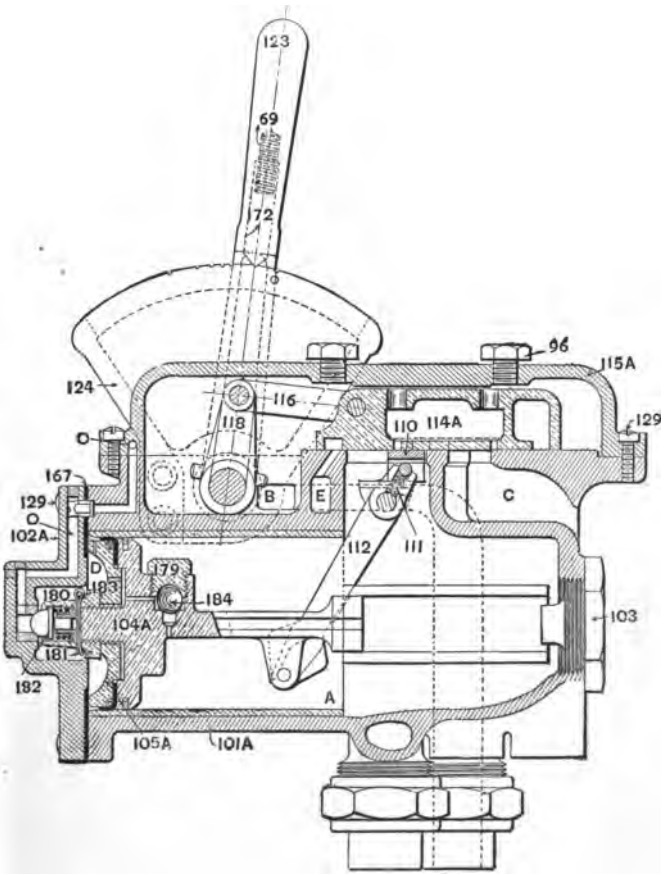


FIG. 31.—LAP POSITION.

H, *J*, and *K* into cavity *C* and out to the atmosphere; chamber *D* is thus emptied. With no pressure in chamber *D* the train-pipe pressure in chamber *A* forces piston 104*A* to the extreme left.

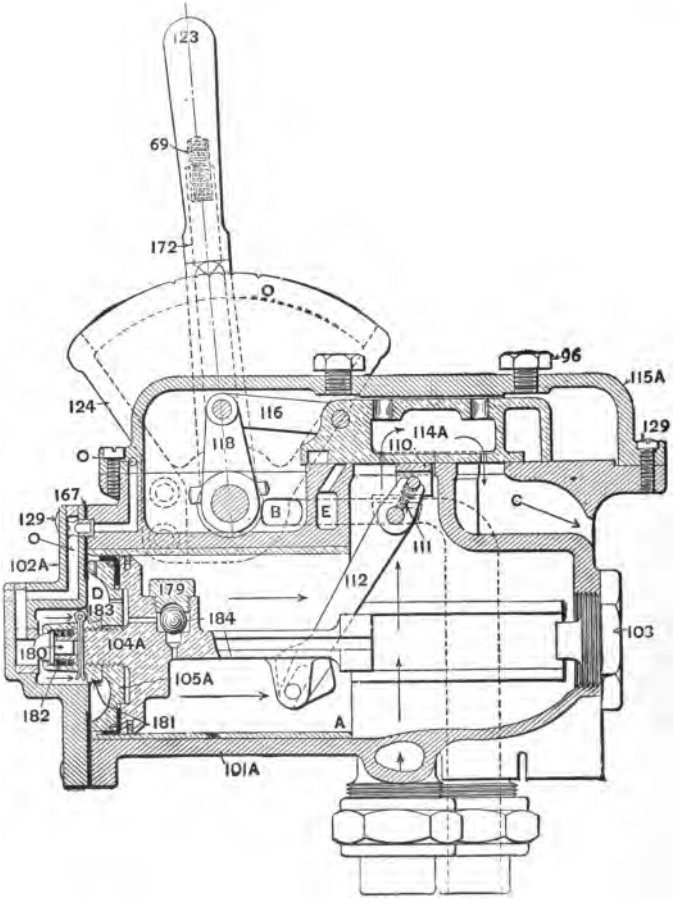


FIG. 82.—SERVICE GRADUATING POSITION.

Q. What should be done when the valve is placed in release position?

A. It should be left there long enough to permit

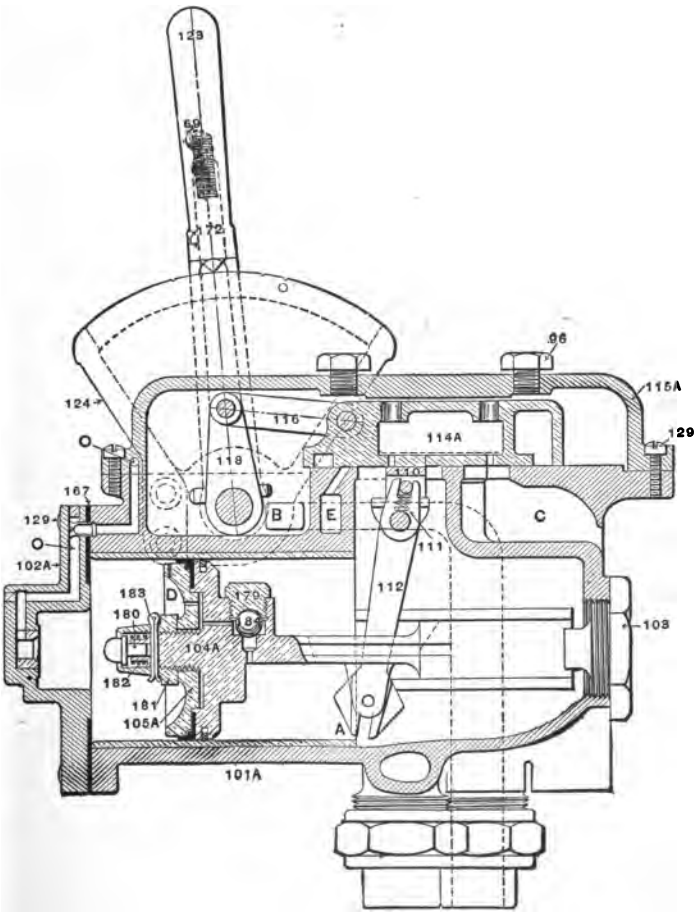


FIG. 33.—AUTOMATIC LAP POSITION.

all the air in chamber *D* to escape or piston 104*A* will not be moved to its proper position at the left (Fig. 18).

Q. What should be done before applying the brake after the valve has been returned to running position?

A. Leave the valve handle in running position long enough to charge chamber *D* or supplementary

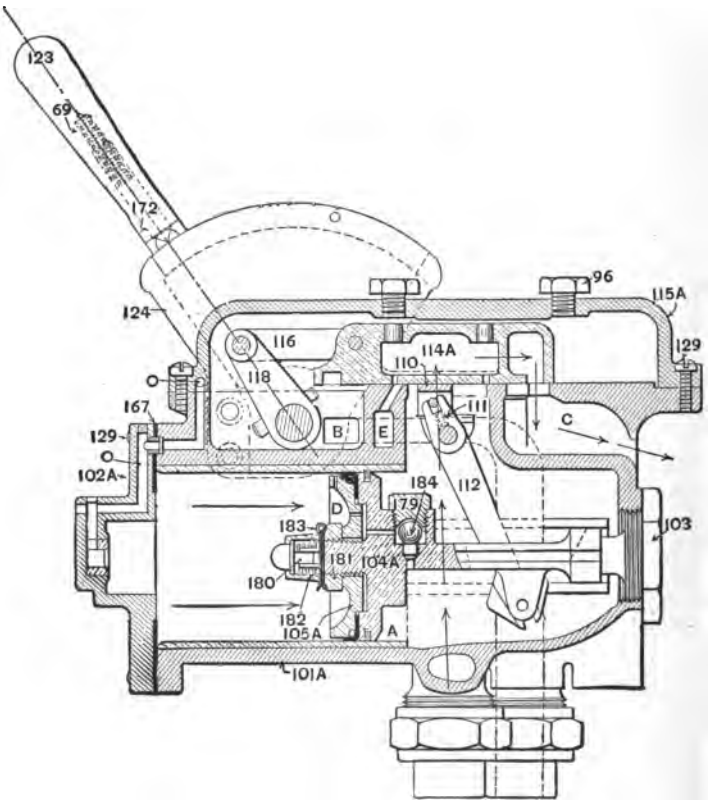


FIG. 34.—EMERGENCY POSITION.

reservoir 155 (Fig. 23), which is connected to the brake valve as indicated in Fig. 16.

Q. What will happen if the valve is moved to service position direct from full release?

A. There will be no air in chamber *D* to force piston 104*A* to the left and cause the graduating valve 110 to close port *F*. As a result the brakes will apply with a full service application.

Q. What is the object of port N in the slide valve (Fig. 22)?

A. In some of the very first forms of slide valve this port was not used, with the result that the brake-valve handle could be placed in a false lap position between release and running in which no air could reach the train pipe to supply leakage and charge the auxiliary reservoirs. This was a dangerous position which has been eliminated by inserting the port *N* as shown in Figs. 22 and 25.

Q. By what pressure is the pump governed?

A. This point is explained in the chapter on the pump governor.

Peculiarities and Troubles of the Brake Valve.

Q. With this valve, will the pump stop before boiler pressure is obtained if the handle of the valve is left in service position?

A. Yes.

Q. Why?

A. Because the pump governor is piped to chamber *E* (Figs. 17 and 20), and this is charged, even the brakes are applied, since main reservoir pressure is always free to pass into chamber *E* when strong enough to force valve 97 from its seat.

Q. What would result from dirt on the seat of valve 97?

A. We would get no excess pressure, and the pump would not start to work after it stopped until both main reservoir and train-pipe pressure leaked below 70 pounds. This is because the dirt on the seat of the excess pressure valve permits the train pipe and main reservoir pressures to run together. Under these conditions a prompt release and recharge could not be accomplished.

Q. What would result if spring 90 had too much tension?

A. We would obtain more than 20 pounds excess pressure.

Q. What if it were too weak?

A. We would obtain too little excess pressure, and brakes would be liable to stick when making a release on a long train.

Q.. What effect would be noticed if the seat of slide valve 114A leaked?

A. We might not be able to obtain any excess pressure, and after the brakes were applied the leak would tend to release them. Lap position would also be destroyed if the leak were bad; such a defect, however, would be noticeable only on a short train, as the leaks on a long train would counteract the defect.

Q. What should be done if the handle 123 (Fig. 18) works hard?

A. Remove the oil plug 96 (Fig. 18) when there is no main reservoir pressure and drop a little oil on the valve seat when valve 114*A* is at its extreme positions to the left and right.

Q. How much train-pipe reduction will be made if the last service notch is used?

A. From 23 to 25 pounds.

Q. If a 10-pound reduction of train-pipe pressure were made, and the brakes were released by placing the brake valve handle in running position, how would the brakes respond when the valve was again placed in the service notch?

A. No response whatever will ensue until the brake-valve handle has been placed in the notch beyond the one used to make the 10-pound reduction.

Q. Why is this so?

A. Owing to the fact that the train pipe was recharged without permitting the pressure in chamber

D to escape, the piston 104*A* and the graduating valve 110 were not moved to their normal positions, and the service port cannot be opened until the brake-valve handle has been moved as already described.

Q. How can it be ascertained if the slide valve 114A leaks?

A. Make a light service reduction with engine alone and watch the black gage hand; if it rises the slide valve is leaking.

Q. What effect will be produced if the packing leather in piston 104A leaks?

A. The train-pipe exhaust will not close off properly when the brake-valve handle has been placed in a service notch.

Q. Could a leak at any other point produce this effect?

A. Yes; a leakage at any of the joints between chamber *D* and the supplementary reservoir would produce the same effect, but the trouble will usually be found in the piston leather.

Q. What could an engineer do in case the train-pipe exhaust would not quite close?

A. Move the brake-valve handle slightly toward lap position.

Q. What test will usually decide if this leather is leaking?

A. Aside from the action of the valve as just described, the following test can be made: Place the brake-valve handle in emergency position, turn the cut-out cock under the brake valve and place the valve handle in one of the service notches. If the black

gage hand rises the packing leather leaks, if the slide valve and joints are known to be tight. A test to determine these points should be made before testing the leather.

Q. How can the excess pressure valve be removed?

A. By closing the cut-out cock under the brake valve, draining the main reservoir, and removing the cap 98.

Q. What may cause a slow recharge when the brake valve is in release position?

A. Any lost motion on the inner end of the handle shaft and in the links and pins between the handle and the slide valve 114*A*.

Q. In the older type of valve, what has been known to happen due to the jar of the engine?

A. The equalizing piston has been jarred to the right, moving the graduating valve so that the proper service response would not be obtained when the brake-valve handle was placed in a service notch.

Q. Could this occur with the latest type of brake valve?

A. No; if in release, running, or lap positions the piston was jarred to the right, port *O*, connected with the atmosphere in these positions, would discharge pressure from chamber *D* to the atmosphere and train-pipe pressure at the right of the piston would again force it to its normal position at the left.

1902 Model Brake Valve.

Q. Name the additional parts of this valve not found in the former type of valve.

A. 105*A* (Fig. 29) is the follower; 184, the ball check valve; 179, the check valve cap; 180, the vent valve; 181, the follower cap nut; 182, the vent valve spring; and 183, the cotter pin.

Q. Port H, shown only on end view in the cuts of 1902 valve, but shown in Fig. 24, has what duties to perform?

A. It serves to charge the supplementary reservoir and connect this reservoir with chamber *D*, but does not connect with port *J* as shown in Fig. 27. It begins in chamber *D*, extends back lengthwise of the valve (Fig. 24), and as shown at 155 (Fig. 16) has a connection which is piped to the small or supplementary reservoir.

Q. Where does port O lead?

A. As shown in Figs. 27 and 28 it leads up into the cover 115*A*, and from this point it is drilled back where it connects with a port in the valve seat. In release position it is connected with the atmosphere through port *J* in the slide valve and the exhaust port *C* in its seat. In running and lap positions port *O* leads to cavity *P* in the slide valve (Fig. 25) which connects with exhaust port *C* (Fig. 29).

Q. What is the duty of port O?

A. At the time the brakes are released it is necessary to return the equalizing piston to its normal position at the left (Fig. 29). In order to do this it is necessary to discharge the air at the left of the equalizing piston to the atmosphere. As just described, port *O* leads to the atmosphere in release, running and lap positions; consequently the air will be discharged to the atmosphere in any of these positions, and the train-pipe pressure in chamber *A* will force the piston to its normal position.

Q. As soon as the piston is in its normal position vent valve 180 is seated. What happens now?

A. With no pressure in chamber *D* there is no air above the ball check valve 184 to hold it to its seat, and train-pipe pressure in chamber *A* lifts the check valve, passes through the small ports of the piston into chamber *D*, and out through port *H*, connected with chamber *D*, to the small or supplementary reservoir, charging chamber *D* and the supplementary reservoir to a pressure equal to that in the train pipe.

Q. When a reduction of train-pipe pressure is made can pressure in chamber D feed back into the train pipe?

A. No; the train-pipe pressure being less than that in chamber *D*, permits the pressure in this chamber to hold the check valve to its seat.

Q. What advantages are gained with this valve?

A. The equalizing piston will be forced to its normal position in release, running or lap positions and, in either of these positions, the equalizing reservoir can be recharged?

Q. If a 10-pound reduction be made with the older type of valve and a release is made in running position, no action of the graduating feature could be obtained in a service notch until the brake-valve handle had been moved beyond the service notch which had been used before, since the graduating valve remained in this position owing to the fact that chamber D pressure was not exhausted to the atmosphere in running position.

Q. Could this action occur with the 1902 valve?

A. No; since port *O* is connected with the atmosphere in release, running, and lap positions, and the discharge of chamber *D* pressure to the atmosphere would return the piston to its normal position.

Q. What would happen if dirt accumulated on the seat of the vent valve 180?

A. It would simply be a slight leak which would be supplied by air that would feed by the ball check valve 184 from the train pipe.

Q. What would result if dirt or gum accumulated on the seat of the ball check valve 184?

A. When a reduction of train-pipe pressure was made, the tendency would be for air from chamber *D* to feed back into the train pipe and destroy the graduating feature of the valve. The effect would be the same as a poor packing leather 107 (Fig. 29) or gasket 167.

What was said of the peculiarities of the former type of brake valve also refers to the 1902 model, with the exceptions noted, but the peculiarities given under the head of the 1902 model valve refer to it alone.

Old-Style New York Engineer's Brake Valve.

Q. What pressure is in cavity 31 above piston 32 (Fig. 36)?

A. Train-pipe pressure.

Q. What pressure is below piston 32?

A. Main reservoir pressure. Air feeds in from the main reservoir through the hole to the right of piston 32 into the cavity below the piston.

Q. Of what use is the spring 33?

A. The tension of this spring acting on the system of levers is such that the downward action of the spring and levers on piston 32, combined with the train-pipe pressure above the piston, just balances the main reservoir pressure acting under it.

Q. What would happen if piston 32 were raised?

A. The higher the piston rose, the shorter (horizontally) would be the lever arm 34, and the greater would be the lever arm 36 below the fulcrum 46, on which the spring 33 exerts its power. Therefore, the higher piston 32 rose, the more resistance it would meet, due to spring 33 acting on the increasing leverage.

Q. Of what use are the five different positions?

A. The same as the positions described with the other brake valve.

Q. What position of the valve is shown in Fig. 36?

A. Running position.

Q. Explain full release position.

A. When the handle 50 is moved to this position,

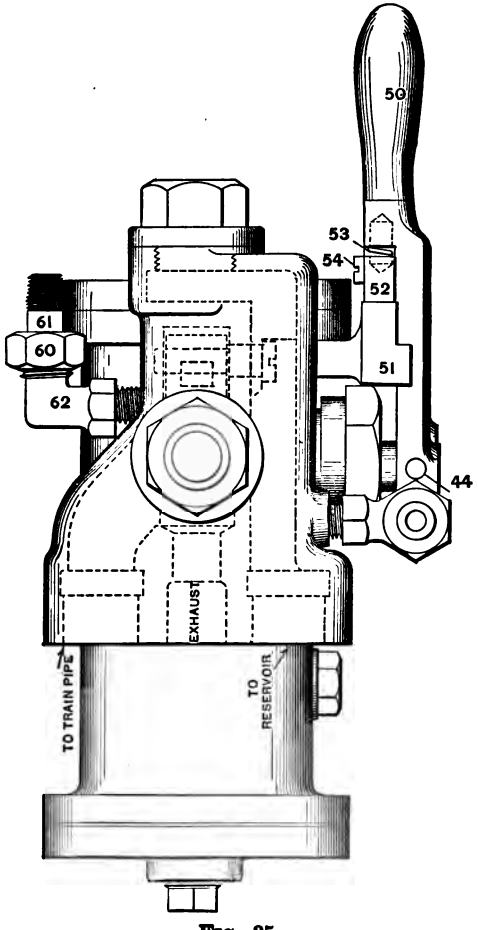


FIG. 35.

the eccentric pin 44 is lowered from its position in the cut. This causes the link 66 to exert a downward pull on the lever fulcrumed at 47, and lowers the right end of lever 67 so that it clears the lifting pin of valve 42, and train-pipe pressure holds this valve to its seat. As link 66 is lowered, the lever 65 is raised, and this forces the main feed valve 64 from its seat, allowing main reservoir pressure to feed direct to the train-pipe or chamber 31. Main reservoir pressure is connected direct with the cavity above valve 64, as shown by the dotted lines in Fig. 35.

Q. Explain running position.

A. Moving handle 50 to running position, we have the position of the valve as shown in Fig. 36. The eccentric pin has been raised so that the valve 64 is closed, but the feed valve 70 still remains unseated. For main reservoir pressure to reach the train pipe it now has to force valve 68 from its seat, and pass down by the feed valve 70 into the train pipe. The spring 69 has a tension of 20 pounds, therefore the main reservoir pressure must be 20 pounds in excess of that in the train pipe before it can feed by valve 68. It is this spring that gives us our excess pressure.

Q. Explain lap position.

A. The movement of handle 50 to lap position raises the eccentric pin just enough for the lever 65 to lower valve 70 to its seat, and the main reservoir pressure is shut off entirely from the train pipe.

Q. Explain the service position.

A. Moving handle 50 to service position, raises the eccentric pin far enough to cause the right end of lever 67 to unseat valve 42, allowing train-pipe

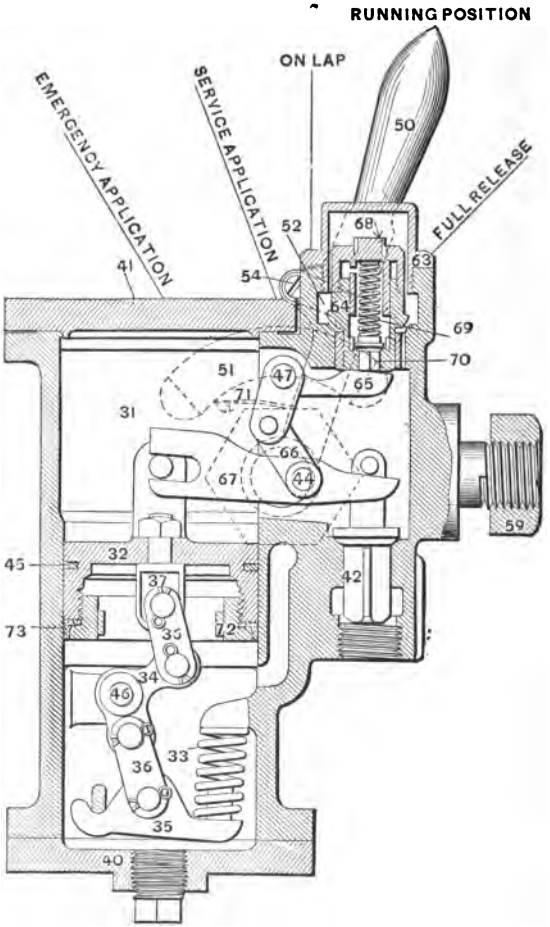

RUNNING POSITION
ON LAP
EMERGENCY APPLICATION
SERVICE APPLICATION
FULL RELEASE
50
52
68
63
41
54
64
69
70
51
47
65
71
31
66
67
44
59
45
32
37
42
73
35
72
34
46
33
36
35
40

FIG. 36.

pressure to escape to the atmosphere. As train-pipe pressure is reduced above piston 32, the main reservoir pressure gradually raises it an amount governed by the reduction made above piston 32. The pin 44 remains stationary and as piston 32 rises it lifts the left end of lever 67 and lowers the right end, allowing valve 42 to seat. If another service reduction is desired, the handle 50 is again moved toward emergency position sufficiently to raise valve from its seat, and again piston 32 will be raised automatically and seat valve 42. It is in this that we see the use of spring 33 and the levers, the operation of which we have already considered.

Q. Explain the emergency position.

A. When handle 50 is moved to emergency position the pin 45 is lifted so high that the lever 67 raises valve 42 up full stroke, causing a sudden train-pipe reduction which causes the triples to respond in quick-action.

Q. With brake valve handle in emergency position, can piston 32 raise sufficiently high to close valve 42?

A. No.

Troubles and Peculiarities of the Old-Style Engineer's Brake Valve.

Q. What is the probable trouble if too much or too little excess pressure is obtained with the brake valve in running position?

A. In the first case spring 69 would be too strong, while in the second it would be too weak.

Q. In the running position what could prevent our having any excess pressure?

A. Dirt or a poor seat on valve 68, a leak by valve 64 or piston 32.

Q. What would destroy lap position?

A. Dirt on the seat of valve 70. In such a case pressure would continue to feed into the train pipe, and if the brakes were applied, the increase in train-pipe pressure would release them.

Q. What is the probable cause if air does not feed through fast enough to release brakes quickly with the brake valve in release position?

A. It is likely that the strainer in the main reservoir connection is partly or entirely filled with dirt.

Q. What would result if spring 33 were broken?

A. Piston 32 would rise so high that it would be difficult to apply the brakes with the service application, and we might not be able to get the emergency at all, as valve 42 could not be raised sufficiently high from its seat.

Q. What effect will a leak on the seat of valve 42 have?

A. It will keep the pump working to supply it when the brakes are not applied, and, after they are applied, the leakage will cause the brakes to creep on harder.

Q. What would result if link 65 or 66 were broken?

A. The brakes could not be released.

Q. What would result if the levers below piston 32 were broken or disconnected?

A. Piston 32 would rise so high that it would be doubtful if the brakes could be applied, especially on a long train, and the emergency would be destroyed entirely.

Q. What effect would excessive wear on 65, where valve 70 rests, produce?

A. Running position would be destroyed if the wear were sufficient for valve 70 not to be held from its seat. In full release position valve 64 would not be raised the proper amount, and air would not enter the train pipe so fast from the main reservoir. The handle would need to be moved a little past running position toward full release to get valve 70 unseated and have the conditions of running position.

Q. If the valve is in a very warm place what should be done?

A. The leather 73 should be oiled sufficiently often to keep it from cracking.

Q. Of what use is plug 40?

A. To drain off any accumulation of water.

Q. What would result if packing 73 dried out?

A. Main reservoir and train-pipe pressure would equalize and the equalizing feature of the valve would be destroyed.

Q. What would happen if the packing leather 73 dried out?

A. Main reservoir and train-pipe pressures would equalize, and the equalizing feature of the brake valve would be destroyed.

Q. With this valve the pump governor was controlled by train-pipe pressure; what would occur when the brake was applied and the handle was on lap?

A. The train-pipe pressure being below 70 pounds, there would not be sufficient pressure to operate the pump governor, and the pump would continue to operate as long as the brake-valve handle was on lap, or at least until the main reservoir pressure was practically equal to that in the boiler.

Q. Could this high pressure not be avoided in any way?

A. Only by partly closing the pump throttle.

Q. How is this trouble overcome with the present valve?

A. By connecting the pump governor to chamber *E* or by using a duplex governor, one head of which is connected to train-pipe pressure and the other to main reservoir pressure. In this way it is impossible to obtain too high a pressure.

Air Pumps.

Q. How many sizes of New York pumps are manufactured?

A. Two, known as the No. 1 Duplex and the No. 2 Duplex.

Q. For what service is each intended?

A. The small one is recommended for light engines; and the No. 2, or the larger pump, for heavy engines.

Q. Are the two pumps alike in construction?

A. The principle and location of the parts are identical. The only difference is in the size of the parts and ports.

Q. Give the names of the different parts of the pumps?

A. 5 and 6 are the reversing slide valves; 7 and 8 are the reversing slide-valve rods; 31 and 32, the air pistons; 21 and 22, the steam pistons; 9 and 10 are receiving valves for the low-pressure cylinder 4; 9, 10, 11, and 12 act as receiving valves for cylinder 3, 11 and 12 as discharge valves for cylinder 4; 13 and 14 are discharge valves for the high-pressure cylinder 3.

Q. What are the diameters of the cylinders in the small pump?

A. The two steam cylinders and the high-pressure

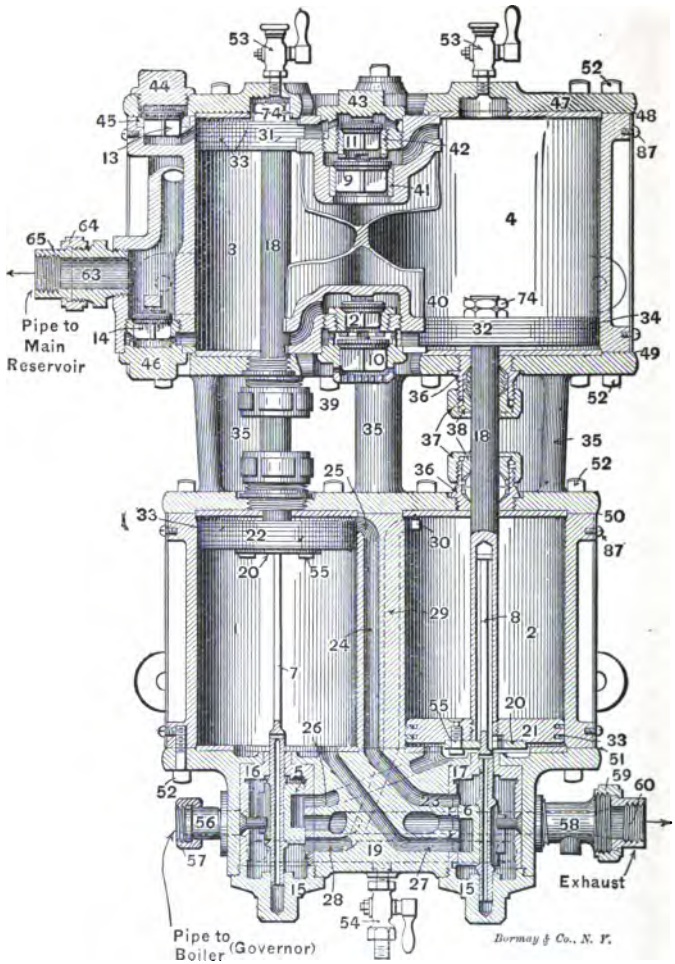


FIG. 37.—DUPLEX PUMP HORIZONTAL SECTION.

air cylinder are each 5 inches in diameter. That of the low-pressure air cylinder is 7 inches.

Q. What are the corresponding cylinder diameters in the large pump?

A. 7 and 10 inches.

Q. What pressure is always in the reversing slide valve chambers just below Figs. 16 and 17?

A. The steam pressure admitted from the boiler by the pump governor.

Q. What controls the passage of steam from these chambers?

A. The reversing valves 5 and 6 operated by the reversing rods 7 and 8.

Q. Where does port 19 lead?

A. From one reversing slide-valve chamber to the other, as shown by the dotted lines (Fig. 37).

In the explanation of the working of the pump we will consider it as being started when both pistons are at the extreme upper end of their strokes; with the pump in this position both reversing slide valves are also at the top of their strokes.

Q. Explain the passage of steam with the reversing slide valves in this position.

A. Port 27 is exposed, allowing steam to pass from the reversing slide valve chamber at the right, through port 27 into the lower end of cylinder 1 beneath the steam piston 22, and any steam above this piston could pass through ports 25, 24, 23, through the exhaust cavity of valve 6 and to the atmosphere through the exhaust port.

The steam in the reversing slide-valve chamber at

the left would pass through ports 28, 29, and 30, to the upper side of piston 21, and any steam on its under side would pass through ports 26, the exhaust cavity of valve 5, and out to the atmosphere through the exhaust port.

Q. We now have steam pressure acting up on piston 22 and down on 21. What effect would this have?

A. Piston 22 would be held where it was, while piston 21 would make a down stroke, drawing piston 32 down with it.

Q. What effect would the downward stroke of piston 32 have?

A. As piston 32 descends, the tendency to form a vacuum would lift the receiving valve 9 from its seat and air from the atmosphere would fill the upper end of cylinder 4. The air being compressed in the lower end of cylinder 4 would force valve 12 from its seat and pass into the lower end of cylinder 3. Just before piston 21 had completed its down stroke, the reversing plate 20 would have come in contact with the shoulder on the reversing valve rod 8, and the reversing valve 6 would be forced down to the position shown in Fig. 37.

Q. Explain the passage of steam due to the change in position of valve 6, and also the effect of same.

A. The lower end of cylinder 1 would be connected with the atmosphere through port 27, and the cavity of reversing valve 6. Steam from the reversing valve chamber controlled by valve 6 would pass through ports 23, 24, and 25, on top of piston 22, forcing it down. Steam is still above piston 21 and will hold it at the bottom of its stroke until valve 5 is moved.

Q. Explain the effect produced by piston 31 as it is drawn down by piston 22.

A. The air that was forced into the bottom of cylinder 3 by piston 32 on its downward stroke is again compressed, and when the pressure is slightly greater than that in the main reservoir, it forces discharge valve 14 from its seat and passes through passages 63 and 65 to the main reservoir.

The suction above piston 31 draws receiving valves 11 and 9 from their seats, and the upper part of cylinder 3 is filled with atmospheric pressure.

Q. When piston 22 reaches the bottom of its stroke the reversing plate 20 strikes the shoulder on the rod 7, forcing valve 5 down to its lowest position. What effect has this on the passage of steam?

A. The steam above piston 21 escapes to the atmosphere through ports 30, 29, 28, and the cavity of valve 5. Steam from the chamber controlled by valve 5 passes through port 26 and underneath piston 21, forcing it up.

Q. What is the effect when piston 21 forces piston 32 up?

A. The suction under piston 32 draws the receiving valve 10 from its seat, and allows the lower end of cylinder 4 to fill with atmospheric pressure. Air being compressed above piston 32 forces the discharge valve 11 from its seat and passes into the top end of cylinder 3, which is already filled with air at atmospheric pressure.

Q. Just before piston 21 reaches the top of its stroke, the button at the end of rod 8 is carried up by

the reversing plate 20 and valve 6 is moved up. Explain the passage of the steam and its effect.

A. Steam from above piston 22 passes through ports 25, 24, 23, and through the cavity of valve 6 to the atmosphere. Steam from the chamber controlled by slide valve 6 passes through port 27, underneath piston 22, which is forced up, carrying piston 31 with it.

Q. What effect has the upward movement of piston 31?

A. The suction underneath the piston draws the valves 12 and 10 from their seats, allowing the bottom end of cylinder 3 to fill with air at atmospheric pressure.

The air being compressed above piston 31 forces discharge valve 13 from its seat, and passes down and out at 65 to the main reservoir.

Q. What happens when piston 22 reaches the top of its stroke?

A. The reversing plate strikes the button at the end of stem 7 and pulls the reversing valve 5 up. One complete cycle of the pump has now been traced.

Q. What is the lift of the different air valves?

A. 1-16 of an inch.

Q. Which is the lead piston of the pump?

A. The low-pressure piston.

Q. What pressure does the low-pressure piston operate against?

A. From 30 to 40 pounds.

Q. Against what pressure does the high-pressure piston operate?

A. It operates against from 30 to 40 pounds at the start, and the movement of the piston gradually increases this amount until it becomes in excess of that in the main reservoir, at which time the discharge valve is unseated. From this point to the end of the stroke the piston operates against main reservoir pressure. The pressure that the high-pressure piston operates against at the beginning of the stroke depends upon the amount of air that the low-pressure piston has forced into the high-pressure cylinder, consequently the condition of the pump, as well as the speed, is an important factor.

Pump Troubles, Peculiarities and Care.

Q. What are the usual causes that produce pounds in the New York pump?

A. Loose piston heads; running the pump too fast before sufficient air pressure has been obtained to produce an air cushion for the pistons; steam condensation cannot be got rid of if the pump is started too fast, this condensation being due to the steam coming in contact with the cold walls of the cylinder, the pistons striking the condensation causes a pound; piston rod packing being in poor condition in the air cylinder, allowing the air to escape and the piston to strike the head; too small lift of intermediate valves, leaky high-pressure discharge valves, and leaky piston-rod packing.

Q. Will any damage be done if the steam cylinder packing is in bad condition?

A. Yes; the escaping steam will be drawn into the air cylinder by the lower receiving valve; the steam, taking the place of the air, will reduce the efficiency of the pump and also permit an unnecessary and considerable amount of water to reach the main reservoir, whence it will pass to the brake system if the air is not properly cooled. In winter this air inlet is likely to be coated over with ice, thus producing an inefficient pump.

Q. What would be the effect if dirt were on the lower receiving valve 10?

A. With piston 32 on its up stroke air would be drawn into cylinder 4, but when the piston descended, the air being compressed below it instead of raising intermediate valve 12, would pass by the unseated valve 10 to the atmosphere. The efficiency of the pump would thus be reduced.

Q. What would be the effect if, instead of being held from its seat, receiving valve 10 were held to its seat?

A. Atmospheric pressure could not be drawn into cylinders 3 and 4, and a lame pump would result. A receiving valve stuck to its seat, although tending to produce an uneven stroke, does not affect the strokes of the pump to the same degree as does a stuck discharge valve.

Q. What effect would be produced if the top receiving valve 9 were stuck from its seat?

A. The same effect, but on the opposite stroke, would be produced as that described with the lower receiving valve 10.

Q. What will be the effect if an intermediate valve leaks?

A. This defect is productive of uneven strokes of the pump; two exhausts are produced close together, and the other pair wider apart. A corresponding leak in the cylinder-head gasket would produce the same result.

Q. What would be the effect if a cylinder-head gasket leaked between the high and low pressure cylinders?

A. The same effect as is produced by a leaky intermediate valve as just described.

The quick stroke is due to air from the high-pressure cylinder acting on the low-pressure piston, and thus aiding the steam acting on piston 21.

Q. What effect would be produced if a discharge valve were stuck open or was broken?

A. One stroke of the pump would be extremely slow, while the other three would be more regular.

Q. Could anything else produce similar results?

A. Yes; the upper air cylinder gasket leaking badly between the cylinder and the discharge valve cavity, or the lower intermediate valve seat may have worked up so that valve 12 does not unseat properly.

Q. What could cause a scarcity of air in the top of cylinder 4?

A. The upper intermediate valve seat may have worked loose, thus destroying the proper lift of receiving valve 9.

Q. How should this pump be oiled?

A. The steam cylinders are oiled according to the work they perform, as in any other steam cylinder; about one drop a minute is usually found to be sufficient for ordinary service. Oil should be used sparingly in the low-pressure air cylinder, but more is required in the high-pressure cylinder owing to the higher temperature. A good quality of valve oil should be used in both the steam and air cylinders, and in heavy freight service it has been found beneficial to use a constant feed in connection with the air as well as the steam cylinder.

Q. If a pump stops what should be done?

A. First examine the pump governor to be sure that it is operating properly. If the governor seems to be in proper condition, jar the steam head lightly; failing to start, close the throttle, open the drain cock of the steam chest, jar the steam head again and open the throttle quickly.

Q. What effect would be produced if the valve rod were broken, the button at its end, or the reversing plate 20 were badly worn?

A. The low-pressure pistons would make an up stroke when steam was admitted, but the high-pressure pistons would remain against the bottom head.

Q. What would be the effect if the reversing valve rod 7 were broken, the button at the end of it, or reversing plate 20 were badly worn?

A. Both pistons, if not there already, would go to the top of their strokes and remain there.

Q. How would back leakage from the high to the low pressure cylinder be indicated?

A. The low-pressure piston would start away quicker from the end at which the leak existed.

Q. How may back leakage by the high-pressure discharge valves be detected?

A. By opening the oil cock when the pump is stopped and when there is a high pressure in the main reservoir. The character of the blow would indicate whether the trouble was in the top or bottom valve, since if it were the bottom valve it would be necessary for the air to blow by the piston packing rings before it could manifest itself at the oil cup opening.

Q. Outline a test that would determine the condition of the air-piston packing rings.

A. With a main reservoir pressure of 90 pounds, and with a pump speed of 30 double strokes per minute, note the amount of suction at the receiving valves. A constant suction during practically the entire stroke indicates that the packing rings are in good condition; if the strong suction is discontinued after the piston has traversed about half of its stroke, the indications point to a poor condition of the packing rings.

Q. What speed of the pump is recommended to produce best results?

A. From 30 to 60 double strokes a minute.

Pump Governor.

Q. Name the different parts of the pump governor.

A. 1 is the steam-valve body; 2, the air-valve chamber; 3, the spring casing; 4, the piston; 24, the packing ring; 5, the steam valve; 6, the steam-valve guide; 7, the cap; 8, the adjusting screw; 9, the jam nut; 10, regulating spring; 11, the upper spring washer; 12, the diaphragm button; 13, the diaphragm; 14, the air-valve seat.

Q. Explain the duty of the regulating spring 10 (Fig. 38).

A. The tension of this spring exerts a downward force on the diaphragm 13 which, on its under side, is subjected to the air pressure which enters at *F*. When the pressure in chamber *A* exceeds the tension of the spring 10, diaphragm 13 is lifted, and air from chamber *A* passes through port *G* into chamber *B* above the steam piston 4.

Q. What effect does air in chamber B have?

A. It forces piston 4 down and the steam valve 5 is seated. The main steam supply is thus closed and the pump, although not stopped entirely, is practically so.

Q. What causes the pump to work slowly after the steam valve has been seated?

A. There are two ways in which this is done. A small amount of steam passes through port *E*, and the

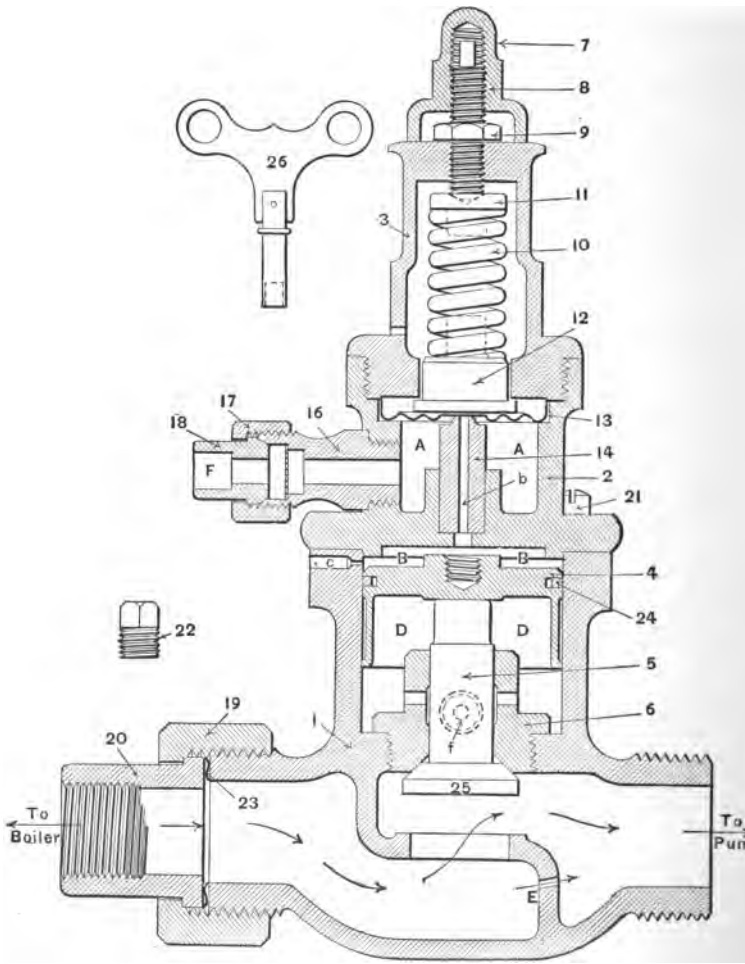


FIG. 88.—PUMP GOVERNOR.

air which escapes from chamber *B* to the atmosphere through port *c* also tends to cause the pump to operate slowly.

Q. How does the air which escapes through port c tend to cause the pump to operate slowly?

A. The air which escapes through this port reduces the air pressure very slowly, and as soon as the pressure in chamber *A* becomes less than the tension of spring 10, diaphragm 13 is forced to its seat and all the air in chamber *B* quickly escapes to the atmosphere through port *c*. With no air in chamber *B* to hold the steam piston 4 down, the steam pressure below the steam valve 5 forces the steam valve and piston up to the position as shown in Fig. 38. Port *c* being very small, the escape of air is necessarily very slow, and a few strokes of the pump will again restore the pressure, at which time the governor, as already described, will automatically seat the steam valve and shut off the main steam supply temporarily.

Q. How is the governor adjusted?

A. Screwing in on stem 8 will cause the pump to shut off when a higher pressure has been attained, and *vice versa.*

Q. To what pressure does the pipe connecting at F lead?

A. It leads to the chamber between the excess pressure valve of the brake valve and the train pipe; so connected it has control of the pump regardless of the position of the brake valve handle. In the running position of the brake valve this chamber constitutes a part of the train pipe volume. The pressure

remains bottled up in this chamber when the brake valve handle is moved toward emergency position and operates the governor to stop the pump until the brake valve is moved to release the brake. If the connection was made direct to the train pipe the pump would start to work as soon as a reduction of train pipe pressure was made to apply the brake. The pump would then not cease to operate until a main reservoir pressure about equal to the steam pressure in the boiler was obtained unless the pump throttle were closed. A modification of this governor, as shown in Fig. 52, is used in connection with double pressure systems, in which case the pipe connecting at *F* is as described later.

Q. Why is it desirable to have the pump operate slowly after maximum pressure has been obtained?

A. To keep up a constant circulation of steam in order not to give it an opportunity to condense. Otherwise it would condense when the pump stopped only to be thrown out of the stack on the jacket of the boiler when it started again.

Peculiarities and Troubles of the Pump Governor.

Q. What defect in the governor would, in response to a reduction of pressure, cause a pump to be very slow to start after it had once been stopped by the governor?

A. The relief port *c* being closed, in which case, after diaphragm 13 had been seated, the air above piston 4 could only escape by leaking past packing ring 24 into chamber *D*, from whence it could escape through the port at which the drip pipe is connected. This connection is shown by the dotted lines toward which arrow 6 points.

Q. What governor defects could cause the pump to stop entirely?

A. The most likely cause would be dirt on diaphragm 13 where it seats, this in combination with relief port *c* being closed. With this combination existing air pressure would reach chamber *B* faster than it could escape by piston 4; hence, the piston would be forced down and the steam valve 5 closed.

The cylinder in which piston 4 operates, being dirty or corroded, in connection with the cylinder being badly worn, might cause the piston to stick and the pump to stop.

Q. What could be wrong with the governor so that the main reservoir pressure could equal that of the steam pressure?

A. If the relief port at the bottom of the spring case were closed and diaphragm 13 leaked around its edges, air would reach the chamber above the diaphragm and the air pressure, together with the tension of the spring, would prevent the diaphragm from lifting. The waste pipe being closed with ice or dirt would produce a similar action, since any steam that leaked by the stem of the steam valve could not escape and would accumulate in chamber *D* and resist the action of any air pressure in chamber *B*, acting to force the steam piston down.

Q. What different conditions of the pump governor would tend to reduce the speed of the pump?

A. Dirt on the diaphragm 13 that would permit air to reach chamber *B* so fast that it could not escape through port *c* with sufficient freedom, in which case piston 4 and valve 5 might be forced part way down. A dirty condition of the governor would also tend to magnify this action; this would be especially likely to be noticed if the drip pipe were dirty and the stem of the steam valve were badly worn.

Oil Cups for the Air Pump Cylinder.

Q. What is the purpose of the oil cups shown in Figs. 39 and 40?

A. To furnish an automatic feed for the air cylinder of the air pump.

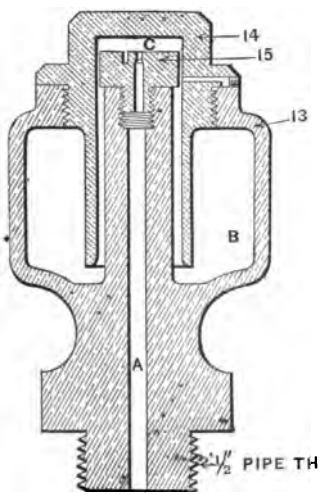


FIG. 89.

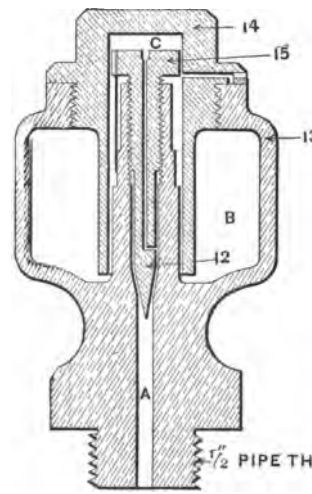


FIG. 40.

AIR CYLINDER OIL CUPS.

Q. Why are oil cups necessary on air cylinders?

A. Practice has shown that, especially in heavy freight service where long air trains are hauled, an automatic cylinder feed is necessary to prevent the

too rapid wear of the air cylinders and rings, and to produce a more satisfactory working pump.

Q. Do the oil cups shown in Figs. 39 and 40 differ in their operation?

A. No; the only difference consists in an adjustable needle feed in the cup illustrated in Fig. 40.

Q. Are both cups in service?

A. Yes; but Fig. 39 represents the standard, and the cup sent out by the New York Company unless the cup (Fig. 40) is specified.

Q. At what point in the air cylinder are the cups screwed in?

A. In the top head of the pump.

Q. Explain the operation of the cups.

A. As the piston makes its up stroke compressed air is driven upward through the passage *A* drilled through the center post in the body of the oil cup; it next passes downward inside the extended sleeve of the cap nut, and then bubbles to the surface of the oil in the reservoir *B* and creates a pressure on the surface. As the air piston makes its down stroke, a vacuum is formed in the passage *A* in the center post, and the air pressure on the surface of the oil, formed when the piston made its up stroke, forces the oil upward inside the sleeve, and a small portion of this oil is drawn into the air cylinder through the very small hole in the feed cap 15, or needle valve 12 (Fig. 40), which screws into the center post.

Q. What regulates the amount of oil fed through the cup?

A. In Fig. 39 port *C* controls the feed, while in

Fig. 40 port *C* and the adjustment of the needle valve control the feed; port *C* may be reduced or enlarged to decrease or increase the amount of oil fed as desired.

Q. How many cups are furnished with each duplex pump?

A. Two; one for the high and one for the low pressure cylinder.

Q. What would render the cup inoperative?

A. Scale or gum closing port *C*.

Main Reservoir.

Q. Where does the air go when it leaves the pump?

A. To the main reservoir.

Q. Where does main reservoir pressure begin and where end?

A. It begins where the air leaves the pump and ends at the engineer's valve.

Q. What is the object of the main reservoir?

A. Its object is to act as a storehouse in which to keep a reserve pressure to throw into the train pipe to release brakes and recharge auxiliaries. It also acts to collect most of the dirt, oil, and moisture that leave the pump.

Q. How much main reservoir pressure is usually carried?

A. Usually from ninety to one hundred pounds, although more is used in mountainous country, when using the High-Speed Brake, the High-Pressure Control, or the Duplex Method of Main Reservoir Regulation.

Q. What size main reservoir is considered proper?

A. One whose capacity is not less than 50,000 cubic inches for freight, and 20,000 or more for passenger engines. It is desirable to have a reservoir capacity of not less than 40,000 cubic inches on passenger engines hauling long trains.

Q. How large should any main reservoir be?

A. In releasing brakes in any service the main

reservoir must be large enough so that, when the brakes are applied and we wish to release them, the main reservoir pressure will equalize with that in the train pipe, when connected with it, at a sufficiently high pressure to insure the prompt and certain release of the brakes, and a quick recharge.

Q. Why is a larger main reservoir necessary in freight than in passenger service?

A. Because there are a greater number of auxiliaries to charge in freight service and a longer train pipe to supply.

Q. When is a large main reservoir with full pressure most essential?

A. After an emergency application, and especially after a break in two.

Q. What results are likely to follow the use of small main reservoirs on engines pulling long trains?

A. Pumps are likely to heat, brakes are likely to stick, and we will have a hard-handling brake valve unless it is oiled frequently.

Q. Why is a pump more likely to heat with a small main reservoir?

A. Because the smaller the main reservoir, the higher the pressure has to be carried, and the higher the pressure the more heat is generated in compressing the air; therefore the pump is more likely to heat and burn out the packing.

A second reason is that with a small reservoir, when releasing brakes, the pump has to work faster to charge the auxiliaries before the speed of the train increases too much. The pump working very fast does

not have time to take in a full cylinder of air each stroke. The pump then has to make more strokes to compress the same amount of air than it would were it working more slowly.

Q. State the gains made by using a large main reservoir.

A. Pressure in the main reservoir and train pipe will equalize higher when releasing, auxiliaries will be charged more quickly, the pump is not so likely to heat, and, not working so rapidly or against so high a pressure, will not wear out so fast, and the brakes are not so likely to stick.

Q. What should be the location of a main reservoir?

A. If possible, at a low point in the air-brake system.

Q. Why?

A. To have all the dirt, water, and oil possible drained into it and drawn off through the bleed cock.

Q. Where is the main reservoir usually located?

A. Between the frames back of the cylinder saddle.

Q. Should it be located there?

A. Yes, when it is possible to place there a main reservoir of the regulation size; but the size must not be sacrificed for the position.

Q. Where else is it sometimes located?

A. Under the foot-boards of the cab and sometimes on the tank.

Q. Is it right to locate it on the tank?

A. Yes, if the requisite volume can be obtained in no other way; otherwise, no.

Q. Why is it not a desirable position?

A. Oil, water, and dirt will not drain into it as they should, and when it is so located, two lines of hose have to run between the tank and engine, one to carry the air from the pump to the main reservoir, and the other to bring the pressure from the reservoir to the engineer's valve. These hose get full of oil and dirt, decay, burst, and in the end prove very expensive.

Q. How often should the main reservoir be drained?

A. At the end of each trip.

Q. Where does this water found in the main reservoir come from?

A. Most of it is drawn from the atmosphere, and given off as the air cools.

The following was taken from the '96 Proceedings of the Air Brake Association. There were four reservoirs, each with a capacity of 12,200 cubic inches, and they could all be used together or cut out at will. The test was made on a twenty-five car train, and shows the advantage of having a large volume of air in the main reservoir to equalize with that in the train line.

Number of reservoirs cut in.	Initial reservoir pressure in pounds.	Initial pressure in train pipe in pounds.	Pressure equalized at in pounds.
4	100	0	50
2	100	0	35
4	100	50	72
4	90	50	67
2	110	50	68
2	100	50	63
2	90	50	61

Q. What is generally conceded to be the best practice concerning main reservoirs?

A. To use two main reservoirs, preferably long and of small diameter, and a cooling pipe of approximately 15 feet between the pump and first reservoir, and 30 feet between the first and second reservoirs.

Q. Why is this done?

A. Tests have shown that, with these conditions existing, air cools properly before passing the brake valve and no water is found in the train pipe, thus doing away with the chance of frozen train pipes.

The accompanying cut represents an automatic drain cock for the main reservoir. This valve is screwed into the main reservoir, and its operation is so simple that an explanation will be unnecessary.

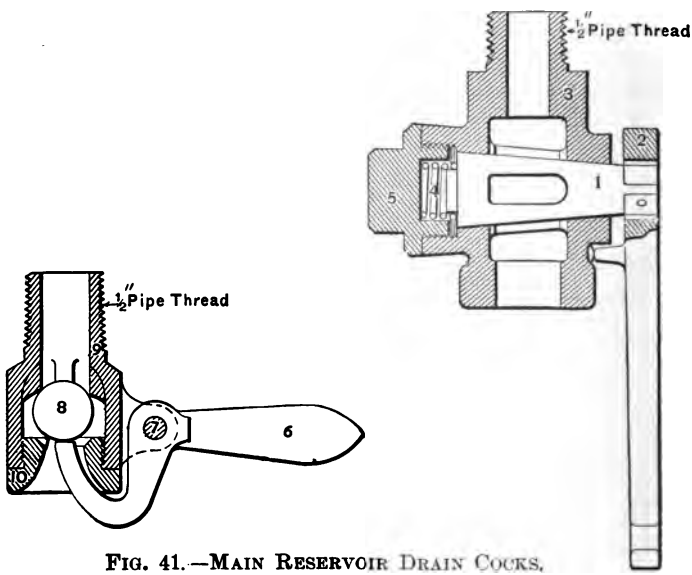


FIG. 41.—MAIN RESERVOIR DRAIN COCKS.

Freight Equipment.

Q. Name the different parts of the equipment.

A. 3 (Fig. 42) is the piston sleeve and head, 9 the release spring, 4 the non-pressure head, 2 the cylinder body, *a* the leakage groove, 7 the packing leather, 8 the expander ring, 6 the follower plate which holds the packing leather 7 to its place, *b* the pipe connecting the triple valve and brake cylinder, and 15 the gasket which makes a joint between the auxiliary, triple, and pipe *b* leading to the brake cylinder.

Q. Explain the use of the release spring 9 (Fig. 42).

A. When the brake is applied, air is put into the cylinder 2 through pipe *b*, and the piston 3 is forced to the left, compressing the release spring. When the air is released from the brake cylinder, the duty of the release spring is to force the piston to release position as shown in the illustration.

Q. What enters the sleeve 3 (Fig. 42)?

A. The push rod through which the braking power is transmitted to the brake rigging.

Q. Of what use is the expander ring 8?

A. To keep the flange of the packing leather 7 against the walls of the cylinder. The expander is a round steel ring.

Q. Of what use is the packing leather 7?

A. As air enters the brake cylinder, the flange of the packing leather is forced against the walls of the cylinder, thus making a tight joint to prevent the passage of air by the piston and out to the atmosphere through the open end of the cylinder at the left. If the leather leaks, the brake will leak off.

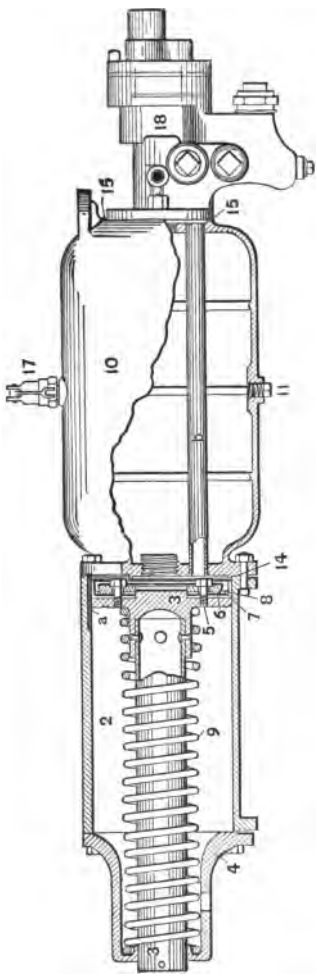


FIG. 42.—NEW YORK FREIGHT EQUIPMENT.

Q. Of what use is the leakage groove a (Fig. 42)?

A. The piston as shown in the cut is in release position. If, on a long train, there should be any leak on the train pipe that would draw a triple piston out far enough to close the exhaust port in the slide valve, and there were a leak into the brake cylinder, the pressure would gradually accumulate and force the piston out, causing the shoes to drag on the wheels were it not for the leakage groove. This will allow any small leakage into the brake cylinder to pass through the groove and out of the other end of the cylinder to the atmosphere.

If the brake connections are taken up so short that the piston will not travel by the leakage groove when the brake is set, the air will blow past the piston through the groove and release the brake on this car. In this case, were it not for the groove, the wheels might be slid.

Q. What is the duty of the pipe b?

A. When the brake is applied, air passes from the auxiliary through the triple and pipe *b* to the cylinder. When the brake is released, air passes from the cylinder through pipe *b*, the triple exhaust port and out to the atmosphere, or, if a retainer is used, it passes from the triple into the retainer pipe, which is screwed into the triple exhaust, and out of the retainer according to the position of its handle.

Q. Of what use is the auxiliary 10 (Fig. 42)?

A. This is where the supply of air is stored with which to apply the brake on this one car.

Q. What is the name and purpose of the valve on top of the auxiliary reservoir?

A. It is called the release valve. By lifting on the handle of this valve the pressure in the auxiliary reservoir 10 may be released. If this valve leaks, after the brake is applied, the reduction of auxiliary pressure thus made will release the brake; when the triple piston is in release position this leak acts the same as a leakage of train-pipe pressure, since it draws air from the train pipe through the feed grooves of the triple valve.

Q. What use has the plug 11?

A. To drain off any accumulation of moisture; in cases where the top of the reservoir is in close con-

tact with the car, the release valve is screwed into the hole now occupied by this plug.

Q. What harm will ensue if gasket 15 leaks?

A. The leak may be from the auxiliary to the atmosphere, from the auxiliary to pipe *b* leading to the brake cylinder, or from pipe *b* to the atmosphere. After the brake is applied, the reduction of auxiliary pressure caused by the first two defects would permit train-pipe pressure to force this triple piston to release position and release the brake. The leak would then draw air from the train pipe through the triple feed ports, making a train-pipe reduction that, with any other train-pipe leaks, would help to creep on the other brakes. A leak from the cylinder to the atmosphere would tend to leak the brakes off gradually on this car when the triple valve had returned to lap position.

Q. Is the freight-car equipment different from the air-brake equipment on a passenger car?

A. It is smaller, constructed and arranged differently, but the principle of operation is the same. In a passenger equipment the pipe *b* does not run through the auxiliary reservoir, and the auxiliary and brake cylinder are not connected. The appearance is different, but aside from arrangement, they are practically the same (see Fig. 7).

Q. What is the purpose of the small hole in the piston sleeve just to the left of number 3 (Fig. 42)?

A. A pin is inserted in this hole when the head is removed for the purpose of cleaning the cylinder. This spring holds the release spring in compression when the nuts, holding the non-pressure head to the cylinder, are removed.

Piston Travel.

Q. What determines the amount of travel a piston will have?

A. The slack in the brake rigging and any lost motion in the car brought out by the application of the brake.

Q. How is the piston travel usually adjusted?

A. By changing the position of the dead truck levers.

Q. Which is called the dead lever of a truck?

A. The one held stationary at the top with a pin.

Q. What is the other lever on the truck called?

A. The live lever.

Q. What is the lever fastened to the piston usually called?

A. The piston lever.

Q. What is the corresponding lever at the other end of the cylinder in a passenger equipment called?

A. The cylinder lever.

Q. Are these levers ever spoken of differently?

A. Yes, sometimes both are referred to as cylinder levers.

Q. In passenger equipment there is sometimes a lever between the cylinder levers and truck levers, one end of which is connected to the hand brake and

the other to the live truck lever. What is this lever usually called?

A. The Hodge, or floating lever; the latter name is the one more commonly used.

Q. We have seen in studying the triple valve that a five-pound train-pipe reduction caused the triple to put five pounds from the auxiliary into the brake cylinder. How much pressure does this give us in the brake cylinder?

A. It depends upon the piston travel. It may be more or less than five pounds; it might be five pounds.

Q. Explain this answer.

A. We notice that the auxiliary is much larger than the brake cylinder, and five pounds taken from the larger space and forced into a smaller one will give a greater pressure than that put in; but it must be remembered that a small part of the air first put into the cylinder goes through the leakage groove before the piston gets by and closes it. There is still another point. If no air were put into the brake cylinder and the piston were pulled out when the exhaust port was closed, a partial vacuum would be formed. When the air enters the cylinder it must first fill this space to atmospheric pressure before a gauge placed on the cylinder would begin to show any pressure. The longer the travel, the more air it would take to fill the space and the less pressure there would be for the five pounds put into it.

Q. Which would give a higher pressure for a given reduction, long or short piston travel?

A. Short travel.

Q. Why?

A. Because with a short travel the same amount of air would be expanded into a smaller space.

Q. With the freight equipment how much brake-cylinder pressure do we get for a seven-pound train pipe reduction with a 6 and a 9-inch travel?

A. Referring to the table, we see seventeen and one-half pounds is obtained with the 6-inch, and eight pounds with the 9-inch travel.

TRAIN PIPE REDUCTION.	PISTON TRAVEL AND RESULTANT CYLINDER PRESSURE *							
	4	5	6	7	8	9	10	11
7	25	23	17½	13	10½	8	PISTON NOT ENTIRELY OUT.	
10	49	43	34	29	23½	19½	17	14
13	57	56	44	37½	33	29	24	20
16	....	....	54	47½	41½	35	29	24
19	....	....	....	51	47	40	36½	32
22	....	....	....	....	50	47½	44	39
25	....	....	....	....	....	....	47	45

*Air Brake Men's 1896 Proceedings.

The above table is the result of tests made with a Westinghouse freight equipment. Each result is the average of several tests, and the brake was in good condition. There are two spaces where it says "Piston not entirely out," where no brake-cylinder pressure is given for a seven-pound train-line reduction. This does not mean there was no pressure there, as there must have been or the piston could not have gone out and compressed the cylinder release spring. The ordinary air gauge does not register any pressure less than five pounds, and with a seven-pound train-line reduction the pressure gotten in a ten- or eleven-inch piston travel is less than five pounds.

Seventy pounds train-pipe pressure was used in making these tests.

Q. With a sixteen-pound reduction?

A. Fifty-four pounds with the 6-inch, and thirty-five pounds with the 9-inch.

Q. With a twenty-two-pound reduction?

A. After the sixteen-pound reduction, the brake did not set any harder on the 6-inch travel because the auxiliary and brake-cylinder pressures equalized at that point, and this brake was full set. With the 9-inch travel the air from the auxiliary had 4 inches more space into which to expand, and the brake was not full set until a twenty-two-pound reduction had been made, giving forty-seven and one-half pounds brake-cylinder pressure.

Q. What does this show?

A. That a brake with a short piston travel is more powerful than one with a long travel; that a brake with the auxiliary and brake-cylinder pressures equalized cannot be applied any harder by a further reduction of train-pipe pressure, and that if piston travel varied in a long train, between 4 and 11 inches, there would be no uniformity in the braking power developed in the different parts of a train.

Q. Can a train be handled smoothly with uneven travel throughout the train?

A. Not as smoothly as when the travel is more uniform.

Q. What will be the effect with short travel at the head of the train and long at the rear?

A. Having more braking power at the head would cause the slack to run in, causing a jar.

Q. What if the short travel were at the rear of the train?

A. The tendency would be for the slack to run out and break the train in two, especially if it were on a knoll.

Q. How else would the piston travel affect the smoothness of the braking?

A. In releasing the brakes.

Q. Suppose we had a train half of which had 4-inch travel and the other half 9-inch, which brakes would start releasing first if the engineer had made a ten-pound train-pipe reduction and then, wishing to release the brakes, increased the train-pipe pressure?

A. They should all start about the same time, but the tendency is always for head brakes to start releasing first if the travel is about alike, as the air enters the train pipe from the main reservoir at the front of the train, and the pressure is naturally a little higher here when recharging.

Q. Is the same true after a ten-pound reduction?

A. Yes.

Q. After a twenty-two-pound reduction?

A. No; the long travel brakes will start releasing first.

Q. Why?

A. Referring to the table, we see that the 4-inch travel was not applied any harder after a thirteen-pound reduction had been made; but the 9-inch travel continued applying harder until a twenty-two-pound reduction of train-pipe pressure had been made. With the brakes full set we have fifty-seven pounds pressure in the auxiliary and cylinder of the 4-inch

travel car and forty-seven and one-half on the long. Train-pipe pressure has to overcome auxiliary pressure to force the triple pistons to release position, and it is easier to overcome forty-seven and one-half than fifty-seven pounds; hence the triple piston on the long travel car will go to release position with less of an increase of train-pipe pressure than will the triple on the short travel car.

Q. State the general rule in regard to this question.

A. If reductions have not been continued after cars with the short piston travel have been full set, all brakes should start releasing about the same time; but if the reductions of train-pipe pressure are continued after the short travel brakes are full set, an increase of train-pipe pressure will start the long travel brakes releasing first, with a strong tendency, of course, for head brakes to start releasing first on account of the pressure at the head end being higher during a release.

Q. If a long and a short travel brake are started releasing at the same time, which will get off first and why?

A. The short travel, because the piston has a shorter distance to go and there is a less volume of air to be gotten rid of through the exhaust port of the triple.

Q. We have two cars with the same piston travel. What is the trouble if both are started releasing at the same time and one gets off quicker than the other?

A. The release spring in one cylinder is weaker, the cylinder is in poor condition or some part may be restricted.

Q. What harm would it do to take a piston travel up to 2 inches?

A. The piston could not get by the leakage groove, and the brake would not stay set.

Q. What harm would it do to let the travel out beyond 12 inches?

A. The piston would strike the head, and we would have no brake on that car.

Q. Does having very long piston travel in a train require any more work of a pump in descending grades?

A. Yes; the air has to be used more expansively, and the pump will have to supply more air in recharging.

Q. If we try the piston travel on a car when standing, will we find it to be the same as when running?

A. No.

Q. Why not?

A. For several reasons; the shoes pull down farther on the wheels when running; the king bolts being loose allow the trucks to be pulled together; spring in brake beams, loose boxes in jaws, loose brasses on journals, the give in old cars, and any lost motion that will throw slack into the brake rigging; all these will cause the piston travel while running to be longer than that while standing.

Q. If the piston travel is adjusted when a car is loaded, will it remain the same when the car is light?

A. It will, if the brakes are hung from the sand plank or column castings, but many brakes are hung

from the truck bolsters or the sills of the car. When the car is loaded, the truck springs are compressed and the shoes set lower on the wheels. When the car is unloaded, the truck springs raise the bolster and car body, thus raising the shoes so that there is less clearance between them and the wheels. This shortens the piston travel, as the piston does not have to move so far to bring the shoes up to the wheels.

Q. How could you tell the piston travel on a car if it had no air in it?

A. This can be told on freight cars where the hand brake and air brake move the push rod in the cylinder in the same direction when applying the brake. To tell the travel, shove the push rod into the cylinder until it bottoms. Make a mark on the push rod and set the hand brake. The distance the mark on the push rod has moved will be, approximately, the piston travel when using air.

Q. How much variation is permissible?

A. The smaller the amount of variation the better, but in road service it is the aim to keep piston travel between 5 and 8 inches.

Q. Is there any device which will keep a constant piston travel on a car without any outside aid?

A. Yes; a slack adjuster.

Q. What slack adjuster is in most general use?

A. The American Brake-Slack Adjuster.

Q. Is this better than a hand adjustment?

A. Yes, because it does its work when the car is in motion, and true travel is had because all lost motion is brought out when the car is moving.

Q. What is the most satisfactory standing travel for general use?

A. Between 5 and 7 inches.

Q. Where would a moderately long travel be considered better than a short?

A. In a practically level country where, with short travel and a large number of air cars in a train, it might be slowed up or stopped with a light train-pipe reduction, thus causing too frequent releases.

Q. What harm results with a travel that is too short?

A. The piston might not get by the leakage groove, and the shorter the travel the more danger of sliding the wheels on account of the greater braking power developed. A too short travel does not give sufficient shoe clearance, and causes a train to pull hard if the brake shoes drag.

Q. On most passenger cars piston travel can be taken up by winding up the hand brake a little, as the two brakes work in opposition to each other. Is this a good practice?

A. No; it is the act of a lazy workman, and is dangerous.

Q. How is it dangerous?

A. If the brake is set quickly, it is likely to snap the brake chain, and if a passenger had hold of a hand brake wheel when the brake was applied, if the dog were not caught, the wheel flying round might break his hand or arm.

Q. If the hand brake on a car works with the air (Figs. 73 and 75), and the air brake was applied,

what would result if the hand brake were then applied?

A. The braking power developed would be too much for the safety of the wheels, rods, etc., since the resultant braking power is equal to the sum of the power of both brakes.

Q. If the air brake were then released what difficulty would be experienced?

A. Since the hand brake retains all of the power of both brakes it would be a very difficult matter for the brakeman to release the brake.

Q. With this kind of a brake what would result if the hand brake were first applied and then the air?

A. If the air brake were more powerful than the hand brake, slack would be thrown into the hand brake chain, and the gain in power would be the excess power of the air over that of the hand brake. If the air power were not as strong as that of the hand no effect would be produced since the pull in the hand brake rod would be diminished an amount equal to the power of the air.

Q. If the hand and air worked opposite, that is, they tended to move the push rod in opposite directions to apply the brake (see Fig. 74), what effect would be produced if the air brake was applied and then the hand brake?

A. The air brake fully applied is usually stronger than the hand brake, hence the pull on the hand brake rod due to the air pressure would be greater than could be exerted by the brakeman, and the brake wheel could not be turned after the slack in the brake chain had been taken up. Under these conditions

no braking power could be gained by using the hand brake.

Q. If the hand brake were first applied and then the air what would be the result?

A. Applying the hand brake took up all the slack in the brake rigging and forced the push rod and piston in as far as they could go. When air from the auxiliary passed through the triple valve to the brake cylinder it would pass through the leakage groove to the atmosphere and simply the power of the hand brake would remain. The clearance in the cylinder being very small would result in a very high pressure when the air first entered, thus tending to strain the rods and brake-chain, but the air would quickly escape as explained.

Q. Which is the better brake from the standpoint of danger to the brakemen?

A. The one in which both work together. If, where the brakes work opposite, a man is using the hand brake at the same time the engineer uses the air, or an air hose bursts, the air power will turn the brake-wheel in the opposite direction tending to throw the brakeman from the train.

Q. If the cars of a train are equipped with air and hand brakes working together, and the train was being controlled by air, what could be done if the engineer lost control of the train?

A. The engineer could call for brakes, and without releasing the air, the crew could add the power of the hand brakes to that of the air.

Q. What would have to be done in a case like this if the hand and air brakes worked opposite?

A. After calling for brakes it would be necessary for the engineer to make a release before the crew could apply the hand brakes, since if this were not done and the hand brakes were applied, any leakage of brake cylinder pressure would allow the piston to move in, thus throwing slack into the brake rigging and releasing the hand brake.

Q. How about leaving cars on a grade if the air brake is applied?

A. If the hand and air work together, the hand brake can be applied without first releasing the air and it will remain set after the air leaks off. If the brakes work opposite, it is necessary to bleed the car before applying the hand brake; if this is not done, the release of the air brake by leakage will also release the hand brake and the car will run away.

To be on the safe side it is best, as a general rule, to always release the air on one car at a time and apply the hand brake, when leaving a car or train on a grade; but this would not be necessary, from the standpoint of safety, if all hand and air brakes worked together.

Q. Are most brakes designed to work together or opposite?

A. A large majority of freight car brakes are designed to work together, while in passenger service the opposite is true; but the importance of this question will result eventually in practically all brakes being designed to work together.

The Retaining Valve.

Q. With what equipments is the retaining valve used?

A. Throughout the country on freight cars, and on engines, tenders, and passenger cars in mountainous country.

Q. Why do they not use it on passenger cars in hilly country?

A. It is not necessary, as the higher braking power used in passenger service is sufficient to run moderate hills with safety.

Q. Where is it located on cars?

A. Usually at the end, close to the brake standard on freight cars, and at the end about on the level of the edge of the hood on passenger cars. On vestibule cars it is located outside of the vestibule at the end of the car.

Q. To what is it connected?

A. To the exhaust port of the triple.

Q. What is its use?

A. To retain fifteen pounds pressure in the brake cylinder to steady the train, and keep its speed from increasing too rapidly while the engineer is recharging the auxiliaries.

Q. How does the handle of the valve stand when not in use?

A. Straight down.

Q. How does it stand when in use?

A. In the position shown in the cut (Fig. 43).

Q. If the brake is not applied, can it be set by turning up the retainer handle?

A. No; the retainer can be used only to hold air in the brake cylinder that has already been put there.

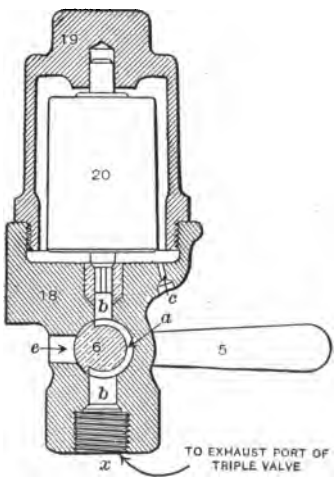


FIG. 43.—PRESSURE RETAINING VALVE.

Q. Explain the passage of the air through the retainer when not in use.

A. With the retainer handle pointing down, as when not in use, any air coming from the cylinder would pass through ports *b*, *a*, and out to the atmosphere through port *e*.

Q. Explain the passage of air through the retainer when in use, as shown by the cut.

A. When the engineer increases his train-pipe pressure the triple assumes release position, and the air passing from the brake cylinder has to pass out through the triple valve exhaust port into the retaining valve pipe to the retaining valve. With the retainer handle turned up, the air passes through port *b, a, b,* until it strikes the weighted valve 20. Any pressure over fifteen pounds forces this valve from its seat and passes through the restricted port opening *c* to the atmosphere. When the pressure in the cylinder is reduced to fifteen pounds, it is held back by the valve 20.

Q. What is the size of the small end of port c?

A. One-sixteenth of an inch in diameter.

Q. Why is it made so small?

A. To keep the brake cylinder pressure from escaping to the atmosphere too rapidly after valve 20 is lifted.

Q. How long will it take the cylinder pressure to reduce from fifty down to fifteen pounds through this retainer?

A. About twenty or twenty-five seconds, during which time the auxiliaries with an average length of train have become pretty well charged.

Q. Have all retainers this restricted port c?

A. No; in some old retainers there are two ports of ¼-inch diameter each.

Q. Will a retainer hold more pressure with a long or a short piston travel on a car?

A. It holds the same pressure regardless of the travel. The volume held is greater on the long

travel car, and consequently any leakage would not release the brake as quickly.

Q. How do we test retainers?

A. Have the engineer apply the brakes, and turn up the retainer handles. Then signal the engineer to release, and wait about a minute, after which walk along and turn down the handles. If a blow accompanies the turning down of the handles, the retainer is working properly, otherwise the pressure has leaked away.

Q. What troubles would make a retainer inoperative?

A. A leak in the plug valve operated by the retainer handle; weight 20 (Fig. 43) being gone or dirt on its seat; a split or leaky pipe leading from the triple exhaust to the retainer, or a leak in the packing leather in the brake cylinder which would allow the air to escape to the atmosphere.

Q. What could be the trouble with the retainer if, after the brake was applied and the retainer put in use, no air escaped from it when the engineer increased the train-pipe pressure?

A. Port *c* might be blocked.

Q. If we wish to use a retainer in descending a grade, should the handle be turned up before or after the brakes are applied?

A. It makes no difference, if everything is in proper condition.

Q. Explain a case where it would not be proper to turn up the retainer handle until just before we wish to use it.

A. If the slide valve in the triple leaked, and we turned up the retainer handle, air would accumulate to a pressure of fifteen pounds in the cylinder if the leakage groove were closed, and set the brake on this car. If the train were just pulling over a summit, the brake being on might stall the train.

Q. Give a rule to produce best results in using the retainer.

A. In testing retainers while standing, turn up the handles at your convenience before or after the brakes are applied; but when using them on the road, turn them up just before the brakes are to be applied.

Q. Is a retainer ever used except to steady a train when recharging?

A. Yes; when brakes have been applied too hard, a few are sometimes used at the head end to keep the slack bunched after releasing, when drifting along preparatory to making a stop.

Q. Set a brake with the full service application, then turn up the retainer handle, release and recharge. After charging the auxiliary in full again, make a full service reduction. Will the brake set any harder one time than another?

A. Yes; it will set harder the second time.

Q. Why?

A. When we started to apply the brakes the first time, we had seventy pounds auxiliary pressure and nothing in the brake cylinder. The second time we had seventy in the auxiliary and fifteen pounds in the brake cylinder. By comparison we see that we had more air the second time with which to do our

braking, and the pressures will therefore equalize higher.

Q. Would we gain more the second time over that of the first with a long or a short piston travel?

A. With the long, because the retaining valve on the long travel car retains the same number of pounds in the cylinder as on the short one, but a larger volume; having a greater volume the pressures equalize correspondingly higher. The gain would be greater but not the actual pressure obtained.

Q. Do we gain the whole fifteen pounds more the second time over what is obtained the first?

A. No; we gain from about three to six pounds pressure, according to the piston travel.

Q. About how much pressure do we get in the brake cylinder for a five-pound train-pipe reduction?

A. It varies from seven to eleven pounds with average piston travel. It may be more or less, but this would be a fair average.

Q. After getting the use of the fifteen pounds that the retainer holds, how much pressure would we then get in the cylinder for a five-pound train-pipe reduction with an average piston travel?

A. Between thirty and forty pounds.

Q. Where a twenty-pound reduction will set a brake in full without the aid of a retainer, how much reduction is necessary with the fifteen pounds it holds to aid?

A. About fifteen pounds with fair travel.

Q. Name another gain after obtaining the use of the retainer.

A. If we have to apply the brakes in full, it does not take so long to recharge, as the auxiliary and brake-cylinder pressures equalize higher with the retainer to aid.

Q. How could we tell if it was safe to turn up a retainer handle before reaching the top of a hill and not have the brakes drag?

A. Put the hand over the exhaust port and hold it there a few seconds to see if any air is issuing; if not, it is safe to turn up the handle.

TABLE.

(1)	(2)	(3)	(4)	(5)
Piston travel	5 Lbs. Serv. Reduction	5 Lbs. Serv. Reduc. with Ret.	Full Service or Emergency.	Full Serv. or Emergency. with Ret.
Inches	Lbs.	Lbs.	Lbs.	Lbs.
4	23	59	57½	61
5	19½	55	55½	59
6	13½	51	53	58
7	11½	43	52	57
8	10	38	50½	56
9	8	35	48	55
10	+	32	46	54
11	+	30	45	53

The above figures were obtained by taking an average of four tests for each condition.

Each test was made with a train-pipe and auxiliary pressure of seventy pounds and a standard freight equipment.

The first column represents the piston travel.

The second column represents the brake-cylinder pressure obtained with a five-pound service reduction.

The third column represents the brake-cylinder pressure obtained with a five-pound service reduction after once obtaining the use of the air held in the cylinder by the use of the retainer.

The fourth column represents the brake-cylinder pressure obtained with a full service or with an emergency application.

The fifth column represents the brake-cylinder pressure ob-

tained with a full service or an emergency application after getting the use of the retainer.

+ simply means that the gauge used registered no pressure less than five pounds. With an 11-inch travel the air is expanded into so large a space that a very small pressure is obtained with a light reduction.

The table should be read from the left to the right.

Combined-Automatic and Straight-Air Brake Equipment for Engines and Tenders.

Q. For what purpose was this equipment designed?

A. For use on engines and tenders in yard and freight service.

Q. Why is it necessary on yard engines?

A. Because a triple valve will not recharge the auxiliary reservoir between very frequent brake applications; as a result it is necessary for the engineer to make a great many stops with the reverse lever. Reversing an engine tends to draw cinders into the cylinders, where they cut the cylinders and packing. The brake on the switch engine should be such that it can be used as often as desirable and always have the maximum power available. Using the brake constantly also keeps the tires in much better condition. A quick release is possible with the straight air, and, if desired, the brake can be partially released.

Q. Of what use is it on road engines?

A. Aside from the advantages stated above, while switching, it provides a means of bunching slack, permits slow-ups to be made to pick up a flag, can be used, if desired, to help retard the speed of the train while recharging in descending grades; also in slowing up at times when much braking power is

not required, and where it is unnecessary to waste the air to apply the brakes on all the cars and thus put needless work upon the pump; and it can be used to meet many similar conditions encountered in road service.

Q. Does this brake operate entirely separate from the automatic, and is there no danger of obtaining too much braking power if one is used without first releasing the other?

A. Each is entirely independent of the other, and the safety valves placed in the pipes leading to the driver and tender brake cylinders will permit only the predetermined amount of pressure considered suitable for maximum braking power.

Q. What are the parts necessary to add to the standard engine and tender equipment?

A. As illustrated in Fig. 44, it is necessary to apply on the engine: One ¾ Straight Air Brake Valve; one Special Reducing Valve; one Double Check Valve; one Safety Valve set at 53 pounds. On the tender: One Double Check Valve; one Safety Valve set at 53 pounds; one piece of hose 1 inch by 36 inches long with nipple and union; two ¾ angle fittings, and one ¾ by 2 inch nipple.

Q. What is the object of the special Reducing Valve?

A. To reduce main reservoir pressure to 45 pounds, that being considered proper with the straight-air brake.

Q. What positions has the Straight-Air Valve?

A. Release, application, and lap positions. In release position cylinder pressure is exhausted direct

to the atmosphere; in application position main reservoir pressure, reduced to 45 pounds, passes through the brake valve to the double check valves and thence to the cylinders.

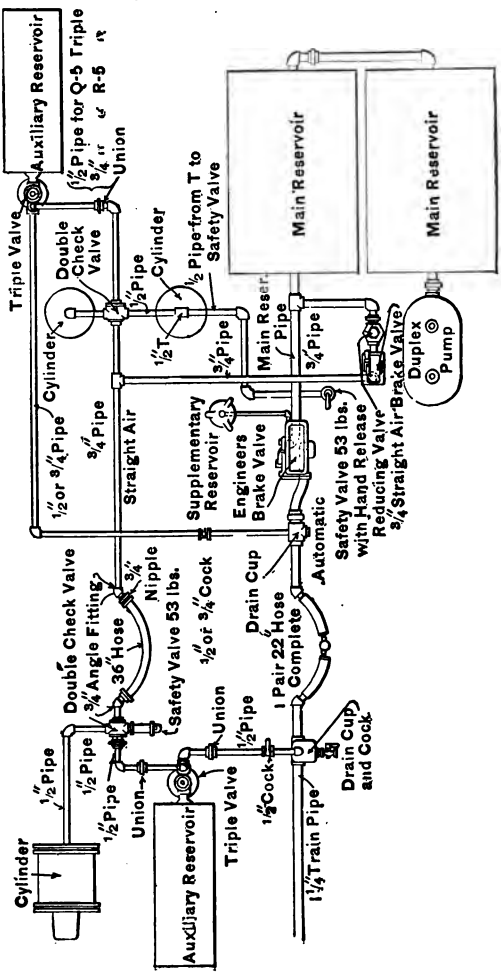


FIG. 44.—DIAGRAM SHOWING METHOD OF PIPING THE COMBINED-AUTOMATIC AND STRAIGHT-AIR BRAKE.

Q. Explain the mechanism of the double check valve (Fig. 45).

A. It consists of a double piston with a leather face on each. When air comes from the triple valve it forces the pistons to the left so that no air can enter through the straight air pipe; a port *(c')* is also opened to permit the air coming from the triple valve to flow to the brake cylinder. When the straight air is used the opposite effects are produced; that is, the

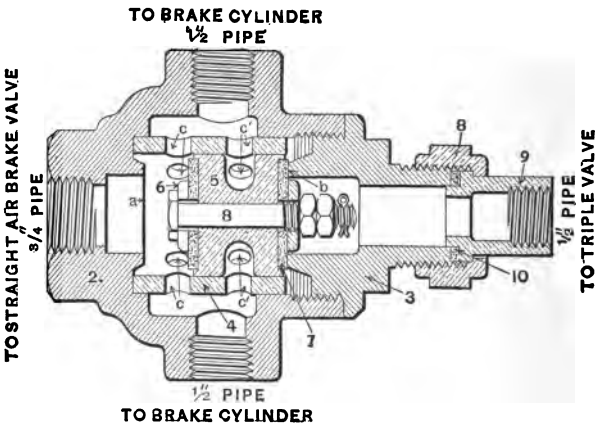


FIG. 45.—DOUBLE CHECK VALVE.

pistons blank the port connection to the triple valve (*c*), and open a port connection (*c*) from the straight air pipe to the cylinder.

Q. What is the object of the safety valves (Figs. 44 and 49)?

A. If the reducing valve did not reduce the pressure properly, owing to its being in poor condition, or if the automatic brake were used without first

releasing the straight-air brake, the safety valve would allow any pressure in excess of 53 pounds to escape.

Q. If the straight-air brake is left partially applied and the automatic is then applied, what will be the result?

A. Nothing unusual will be noticed until the engineer tries to release the automatic, at which time, as soon as the pressure in the pipe between the triple and double check valve is less than that between the straight-air valve and double check valve, the pistons in the double check valve will move over so as to stop the escape of air through the triple and establish a connection between the straight-air valve and cylinder.

Q. How then may the brakes be released?

A. By placing the straight-air valve in release position.

Q. Where should the handle of the Engineer's Brake Valve be placed when the straight-air is in use?

A. In Running Position.

Q. If the automatic brake is partially applied and the straight-air is then used, what will be the result?

A. As just described, with the opposite conditions, the brake could not be released on the engine and tender without putting the Engineer's Brake Valve of the automatic system in Running or Release Position.

The following directions, if properly followed, will produce best results:

1. Always keep both brakes cut in and ready for operation, unless failure of some part requires cutting out.

2. Always carry an excess pressure in the main reservoir, as this is necessary to insure a uniformly satisfactory operation.

3. When using automatic keep straight-air brake valve in release position, and when using straight-air keep the automatic valve in running position; this to avoid sticking of the driver and tender brakes.

4. Automatic must not be used while straight-air is applied; if desirous of using the automatic, first release the straight-air.

5. Though the use of straight-air while automatic is applied will not increase the driver and tender brake cylinder pressure above 45 pounds, yet release of either cannot be assured while the other brake valve is on lap or application position.

6. Bear in mind that the straight-air on the driver and tender brakes is almost as powerful as the automatic brakes on same, and that each should be used with care to avoid rough handling of the train, and loosening of tires on drivers in holding down long grades.

7. The straight-air reducing valve should be kept adjusted to 45 pounds and the driver and tender safety valves at 53 pounds. Where a full application of the straight-air causes either or both safety valves to operate, it indicates too high adjustment of reducing valve or too low adjustment of safety valves. Have them tested and adjusted.

Q. Where is the Straight-Air Brake Valve usually located?

A. On the side of the cab within convenient reach of the engineer when the engine is being run either forward or backward.

STRAIGHT-AIR BRAKE VALVE.

Q. Figs. 46 and 47 show a longitudinal and an end section of the straight-air brake valve. What are its different connections?

A. To the straight-air train pipe or brake cylinder, to the main reservoir, and to the atmosphere as indicated.

Q. Explain the operation of the valve.

A. The main reservoir pressure, as indicated, is always free to reach chamber *A* (Fig. 46). The slide valve 1, controlled by the operating handle 2, controls the flow of main reservoir pressure into port *B* piped to the brake cylinder, and also the flow of air from port *B* (brake cylinder pressure) to the atmosphere through port *D*.

Fig. 46 shows the valve in release position and, as indicated by the arrow, any air in the brake cylinder is free to pass through port *B* and through the cavity of the slide valve into port *D* to the atmosphere.

Moving the controlling handle to lap position, as indicated, destroys the connection between ports *B* and *D* and all ports are blanked.

By moving the controlling handle to the extreme position to the left the slide valve is moved ahead so that air in chamber *A* is free to pass through port *B* to the brake cylinder. This port connection, by

the proper manipulation of the controlling handle, may be made large or small as desired, thus producing either a quick or slow application of the brake. A corresponding quick or slow release may also be obtained as desired.

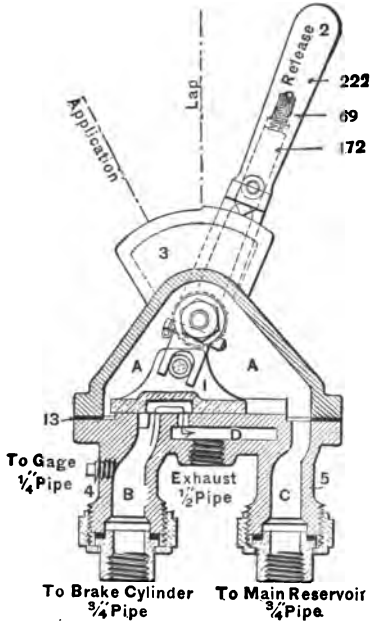


FIG. 46.—LONGITUDINAL SECTION OF STRAIGHT-AIR BRAKE VALVE.

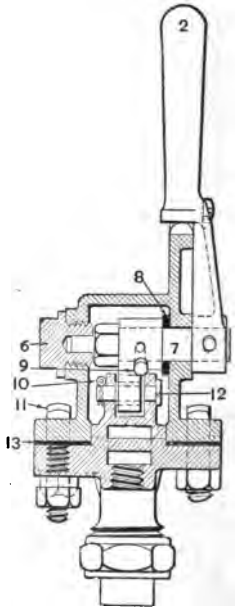


FIG. 47.—END SECTION OF STRAIGHT-AIR BRAKE VALVE.

Q. If the valve handle is allowed to remain in application position how much brake cylinder pressure will result?

A. Forty-five pounds, or that for which the special reducing valve is adjusted.

Q. In what position should the brake valve handle be carried when the brake is not in use?

A. Release position; so placed any slight leakage of main reservoir pressure by the seat of the slide valve will not cause the brakes to creep on the engine and tender, since the air would escape direct to the atmosphere through the exhaust port of the slide valve.

STRAIGHT-AIR REDUCING VALVE.

Q. Name the different parts of the reducing valve (Fig. 48).

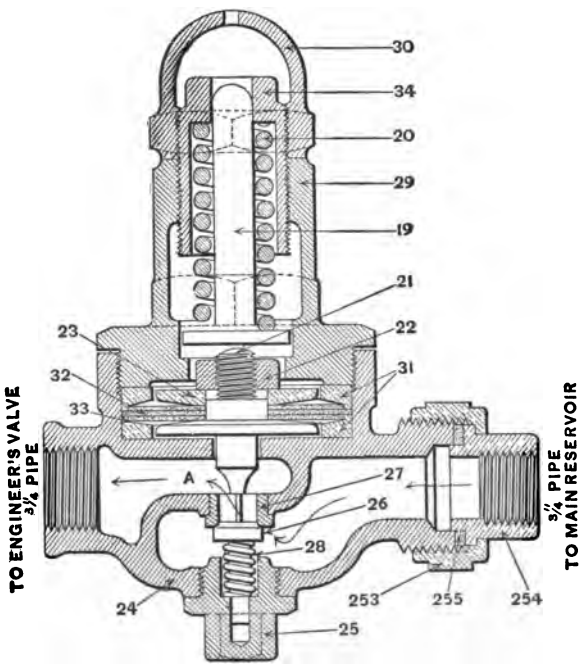


FIG. 48.—REDUCING VALVE FOR STRAIGHT-AIR BRAKE.

A. 19 is the regulating stem; 20, regulating spring; 21, diaphragm stem; 22, nut; 23, diaphragm washer; 24, body; 25, feed-valve cap nut; 26, feed valve; 28, feed-valve spring; 29, spring box; 30, check nut; 31 diaphragm ring; 32, diaphragm; 33, diaphragm shield; and 34, the regulating nut.

Q. Explain the operation of this valve.

A. The tension of regulating spring 20 is adjusted so that a pressure of 45 pounds in chamber *A* will compress it and force the diaphragm up, at which time the feed-valve spring 28 and the main reservoir pressure below the feed valve will force the valve to its seat.

When the pump is first started there is not sufficient pressure in chamber *A* to force the diaphragm up against the tension of the regulating spring 20, hence the diaphragm is forced downward unseating the feed valve 26 and main reservoir pressure flows by the feed valve until the pressure between the reducing valve and the straight-air brake valve is 45 pounds at which time, as already described, the feed valve closes.

When the straight-air brake is used the reducing valve will feed air to the straight-air brake valve whenever the pressure between the reducing valve and the brake valve is less than 45 pounds, or any other pre-determined pressure which is considered a safe cylinder pressure for braking purposes. Practice has demonstrated that 45 pounds is the proper pressure.

Q. What are the chief troubles likely to result with the reducing valve?

A. The rubber diaphragms may rupture, and dirt may collect on the seat of the feed valve 26.

Q. What would be the result if the diaphragms became ruptured?

A. A leak would be produced that would have to be supplied by the pump.

Q. What would result if dirt collected on the seat of valve 26?

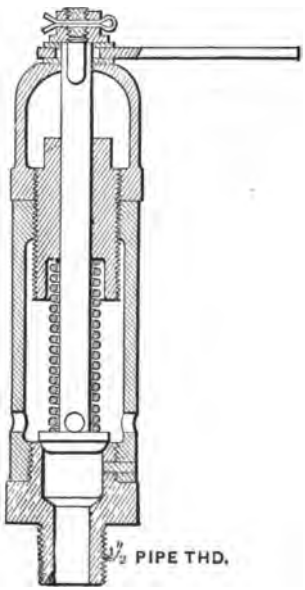


FIG. 49.—SAFETY VALVE.

A. Maximum main reservoir pressure would be obtained between the reducing valve and the straight-air brake valve and, if the brake valve were left in application position, there would be a constant waste of air through the safety valves, shown in Fig. 44, as soon as the brake cylinder pressure exceeded 53

pounds, that at which the safety valves are usually adjusted to open.

Q. What special care should be exercised in putting the reducing valve together?

A. Care should be exercised, especially if a large wrench is used, not to screw the spring box 29 up too tight. If this is done the diaphragms 32 may be crushed sufficiently to make it impossible for feed valve 26 to seat and a high braking pressure will be available with the result that considerable air will be wasted through the safety valves.

Q. How should the reducing valve be located?

A. It should always be located inside the cab and with the spring box on top to prevent any accumulation of water, oil, or dirt from lodging on the diaphragm, and not too near the heat of the boiler.

Q. At what pressures should the reducing valve and the safety valve be adjusted?

A. The reducing valve at 45 pounds and the safety valve at 53 pounds.

High-Pressure Control.

Q. What does Fig. 50 represent?

A. The high-pressure control apparatus.

Q. What special conditions is this equipment supposed to meet?

A. It is designed for the purpose of making it easier to let heavily-loaded freight trains down steep grades.

Q. How is this accomplished?

A. By the use of a duplex or triplex governor on the engine and two safety valves, one on the engine and the other on the tender.

Q. How does this make it any easier to drop heavy freight trains down grades?

A. It permits of either of two train-pipe and main reservoir pressures being carried; the higher train-pipe pressure permits of a greater braking power on the cars but not on the engine and tender.

Q. If a greater braking power is obtained on the cars, why does not a greater braking power also result on the engine and tender?

A. Because the safety valves on the engine and tender brake cylinders, as shown in Fig. 50, will not permit of any greater pressure than that obtained with the usual train-pipe pressure of 70 pounds.

Q. Why is it not advisable to employ any higher pressure on the driver and tender brakes?

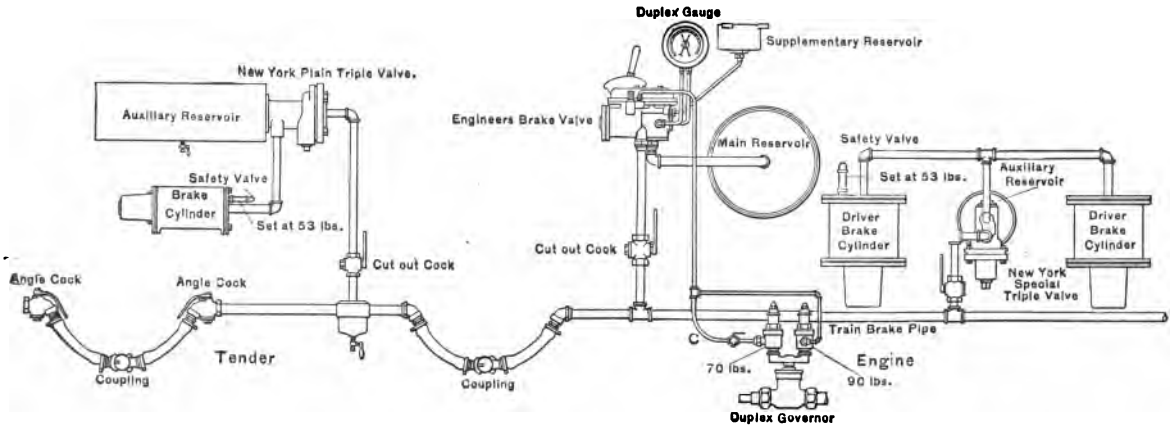


FIG. 50.—DIAGRAM SHOWING METHOD OF PIPING HIGH-PRESSURE CONTROL.

A. Experience has demonstrated that in grade service tire heating is likely to result if a higher pressure is used. Another reason for not using this higher pressure consists in the fact that the weights of the engine and tender vary, hence the liability for wheel sliding would be increased were the higher pressures permitted.

Q. Would there not be danger of sliding the wheels on freight cars when using a higher train-pipe pressure?

A. If used on empty cars, yes; but if used on heavily-loaded cars there would be no danger, as the braking power is usually 70 per cent of the light weight of the car, and when a car is loaded to its full capacity, the percentage of braking power as compared with the combined weight of the car and its contents is very much smaller than this even when using a train-pipe pressure of 90 pounds. The braking power on a loaded freight car approximates 22 per cent of the total weight.

Q. Which is the high-pressure governor Fig. 50?

A. The one at the right.

Q. What does the engineer do if he wishes the usual train-pipe pressure of 70 pounds and a main reservoir pressure of 90 pounds?

A. He opens the small cock in pipe *c*. This governor is adjusted to shut off steam when a train-pipe pressure of 70 pounds has been obtained; the excess pressure valve will give the desired excess pressure of 20 pounds so that when the pump stops there will be a pressure of 70 pounds on the train pipe and a main reservoir pressure of 90 pounds.

Q. In order to obtain a train-pipe pressure of 90 pounds on the train pipe and 110 pounds on the main reservoir what should be done?

A. Simply close the small cock in pipe *c* (Fig. 50). Shutting this cock cuts out the low-pressure governor and the pump will not stop until a train-pipe pressure of 90 pounds has been obtained; the excess pressure valve will have permitted 20 pounds excess to have accumulated in the main reservoir; hence, when the pump stops, there will be a pressure of 90 pounds in the train pipe and 110 in the main reservoir.

Q. Would it be safe to use the 90-pound train-pipe pressure on the train pipe when there were one or two light cars in the train?

A. No damage would result if a hose did not burst, or a heavier reduction than 18 or 20 pounds were not made, in which event the wheels on these cars might be slid.

Q. What is the usual practice under such circumstances?

A. To cut out the one or two light cars.

Q. With a train-pipe pressure of 90 pounds, is any more braking power developed with a 5, 10 or 15-pound reduction than if 70 pounds were carried?

A. No gain will be made unless train-pipe reductions are continued after the point has been reached at which the auxiliary and brake cylinder pressures would equalize when using the 70-pound train-pipe pressure.

Q. Why is this?

A. Because, if calculated, it will be found that

it requires the same number of cubic inches of free air to raise the auxiliary reservoir pressure from 50 to 70, 70 to 90, or 200 to 220 pounds. If the same amount of air is used in each case, the same pressure would result if 20 pounds were taken from the auxiliary, when containing any pressure above 70 pounds, and put into the brake cylinder if the piston travel were not less than 8 inches.

Q. If a reduction of 20 pounds will equalize the reservoir and brake-cylinder pressures when employing an eight-inch piston travel and a train-pipe pressure of 70 pounds, how much reduction will be necessary to equalize these pressures with a train-pipe pressure of 90 pounds?

A. A 26-pound reduction.

Q. How much more powerful would a brake be when using a train-pipe pressure of 90 as compared with 70 pounds?

A. Approximately 25 per cent.

Q. What does Fig. 51 illustrate?

A. This illustrates the latest practice as recommended by the New York Brake Company for either the high-pressure control or the high-speed brake. It is their standard double-pressure system operated by a triplex governor.

Q. At what pressures are the three governor heads adjusted?

A. The one at the left, 70 pounds; the middle one, 90 pounds if used with the high-pressure control, and 110 pounds when used with the high-speed brake; the one at the right is adjusted at from 100 to 140 pounds, according to whether the engine is to be used

in high-pressure control or high-speed service, and according to the condition of country, number of cars hauled, length of train, etc.

Q. If it is desired to use the ordinary 70-pound train-pipe pressure what is done?

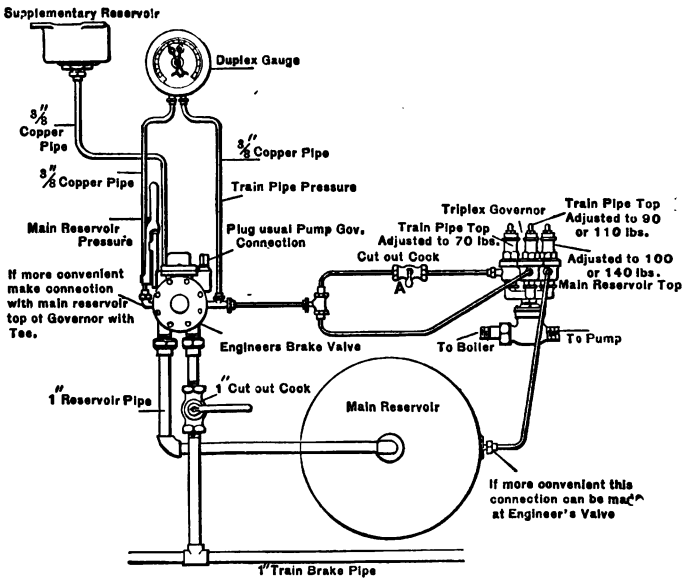


FIG. 51.—METHOD OF PIPING TRIPLEX GOVERNOR.

A. Cut-out cock *A* is left open. With this cock open, and the brake valve in running position, the pump will stop when the train-pipe pressure has reached 70 pounds. When a reduction of train-pipe pressure has been made, and the brake-valve handle is on lap, the pump goes to work and will not stop until the main reservoir pressure has reached that

at which the governor head at the right is adjusted. By the time the engineer is ready to release there will be a high main-reservoir pressure with which to make a prompt release and recharge. With the brake valve in running position the pump will stop when the train-pipe pressure is 70 pounds but the excess pressure valve will give an excess pressure of 20 pounds. During such time as the brake is not applied it will only be necessary for the pump to operate against a pressure of 90 pounds.

Q. What should be done if it is desired to use this equipment with the high-pressure control or high-speed equipment?

A. Close cock *A*. With this cock closed, and the brake valve handle in running position, the pump will not stop until the pressure in the train pipe has reached that for which the middle pressure head is adjusted. With the high-pressure control this would be 90 pounds, while with the high-speed brake it would be 110 pounds. As soon as a reduction of train-pipe pressure is made, and the brake-valve handle is placed on lap, the pump will start to work and not cease operations until a main-reservoir pressure is obtained that will operate the high-pressure governor head at the right. With the brake valve handle in running position a train-pipe pressure of 90 or 110 pounds, according to the adjustment of the middle pressure head, will be obtained, and the excess-pressure valve will give an excess pressure of 20 pounds in the main reservoir. At the time of a release, however, the excess pressure depends upon the adjustment of the high-pressure head at the right.

Duplex Control.

Q. What is the purpose of the apparatus shown in Fig. 52?

A. To provide a means by which a high main-reservoir pressure is available with which a quick release and recharge may be made on long freight trains. This is accomplished in such a way that it is necessary for the pump to operate against a high main-reservoir pressure during only such time as the brake is applied.

Q. What additional parts are necessary to obtain the advantages of this device?

A. An extra pressure head for the governor and a Siamese fitting, as shown in Fig. 52.

Q. At what pressure is it customary to adjust these pressure heads?

A. The one which, as indicated, is connected to train-pipe pressure is set for 70 pounds, while the one connected to main-reservoir pressure is set at 110 pounds.

Q. What objection is there to using one pressure head and adjusting it to stop the pump when a main-reservoir pressure of 110 pounds has been obtained?

A. A pump operating against a high pressure continuously in freight service is much more likely to become overheated.

Q. Explain its operation.

A. As indicated on the cut, the low-pressure head is connected to the train pipe and the high-pressure head to main-reservoir pressure.

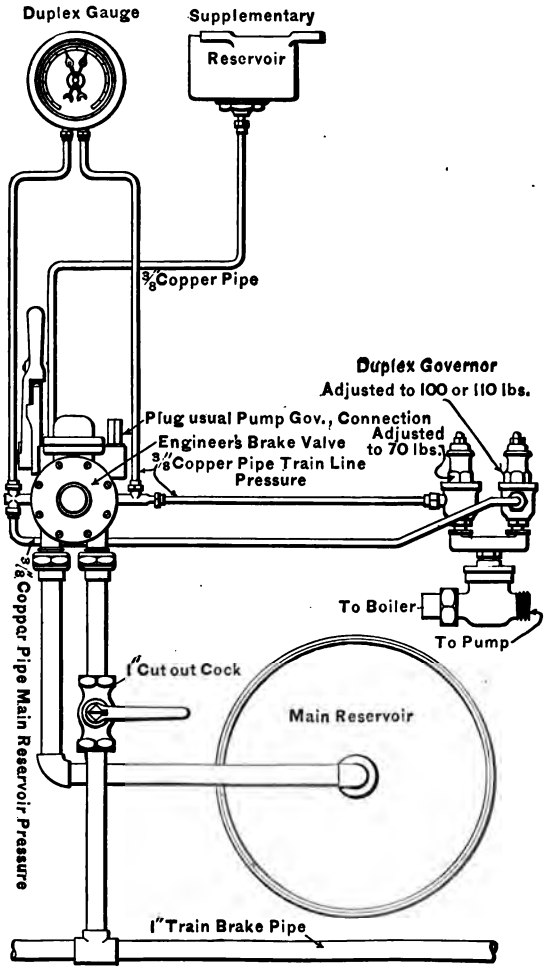


FIG. 52.—DUPLEX CONTROL.

With the brake-valve handle in running or release position the pump is stopped by the low-pressure head as soon as train-pipe pressure reaches 70 pounds. When the brake valve is in running position the excess pressure valve gives the proper excess pressure in the main reservoir.

As soon as the brake-valve handle is moved to service position and the train-pipe pressure is below 70 pounds, the pump immediately starts to work and will not cease operations until main reservoir pressure has reached 110 pounds.

When the brake-valve handle is moved to release position the high pressure assures a prompt release and recharge.

Signal System.

Q. What form of signal was used before the compressed air signaling apparatus was invented?

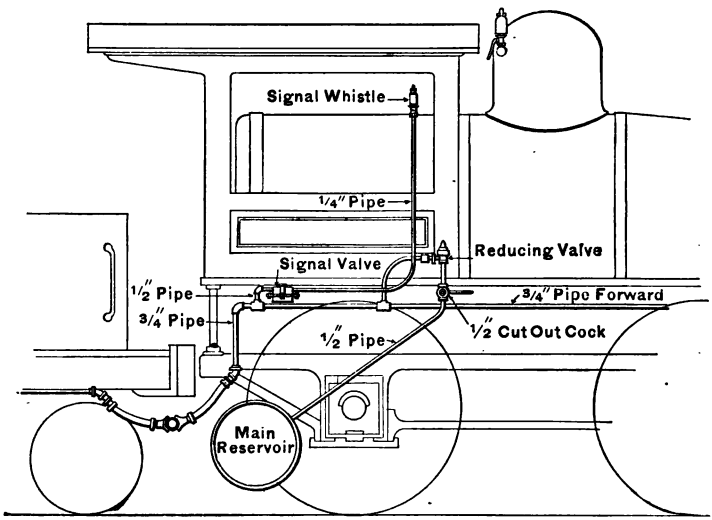


FIG. 53 —SIGNAL EQUIPMENT ON ENGINE.

A. The old bell rope and gong signal, such as is now used on freight trains.

Q. Do all roads use the air signal in passenger service?

A. Not all, but most roads do.

Q. What parts of the signaling apparatus are found on the engine?

A. The reducing valve (Fig. 57), the signal valve (Fig. 56 or 59), the whistle (Fig. 58), and the pipe connections as shown in Fig. 53.

Q. What parts are found on the car?

A. The discharge valve (Fig. 55), the signal cord running the length of the car, and the signal-pipe connections as shown in Fig. 54.

Q. Where is the discharge valve (Fig. 55) usually located?

A. As shown in Fig. 54, although it is sometimes found inside the car over the door.

Q. Why is it better placed outside?

A. When it is so placed the noise of the discharge will not affect nervous people.

Q. How does the car discharge valve operate?

A. The signal cord is attached to the valve in the hole of 5 (Fig. 55); when the cord is pulled, valve 3 is forced from its seat, allowing whistle-pipe pressure to escape to the atmosphere.

Q. What is the trouble when there is a constant leak from the discharge valve?

A. There is dirt on the seat of valve 3 (Fig. 55).

Q. Where is the signal valve (Figs. 56 or 59) located?

A. In the cab, where it will not be subjected to severe heat or cold.

Q. Where is the reducing valve (Fig. 57) usually placed?

A. It was formerly customary to locate it outside, next to the main reservoir, but now good practice locates them inside the cab where they cannot freeze in winter.

Q. What is the duty of this valve?

A. To maintain a constant pressure on the signal pipe.

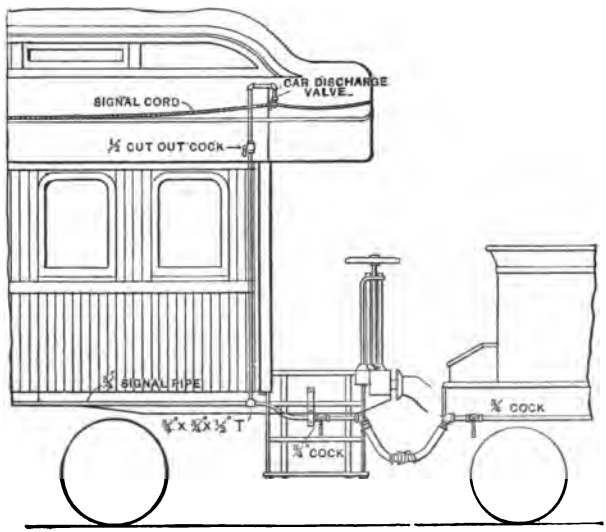


FIG. 54.

Q. Explain the action of the reducing valve (Fig. 57).

A. The top spring has a tension determined by the pressure to be carried on the whistle pipe. This spring holds piston 6 down as long as the tension of the spring is greater than the pressure underneath the rubber diaphragm 7.

As long as the piston is down, valve 5 is held from its seat, allowing main reservoir pressure to feed in as indicated. It passes by valve 5, up under the piston, and into the signal pipe as indicated, until the pressure on the whistle pipe and underneath the diaphragm 7 is greater than the tension of the spring over the piston 6, when the spring is compressed, allowing piston 6 to travel up, and spring 10 raises valve 5 to its seat, shutting off the further passage of air from the main reservoir to the signal pipe.

Q. Where is the whistle (Fig. 58) located?

A. In the cab, as near the engineer as convenient.

Q. To what is it connected?

A. To a pipe which leads from the signal valve as indicated (Figs. 56 and 59).

Q. What is its use?

A. As the signal or whistle valve (Figs. 56 and 59) operates, the air leaving this valve escapes through the whistle (Fig. 58). The blast signals the engineer.

Q. Where does the air come from that supplies the signal system?

A. From the main reservoir on the engine.

Q. Explain the passage of the air from the main reservoir through the signal system.

A. It first passes from the main reservoir (Fig. 53) through the reducing valve. After leaving the reducing valve there is a tee in the pipe, one branch of which leads to the signal valve (Fig. 56 or 59) and the other back into the train. Under each car

(Fig. 54) there is a strainer in a tee, and a branch of the whistle pipe goes to the discharge valve.

Q. What does the conductor do if he wishes to signal the engineer?

A. He pulls the signal cord in the car.

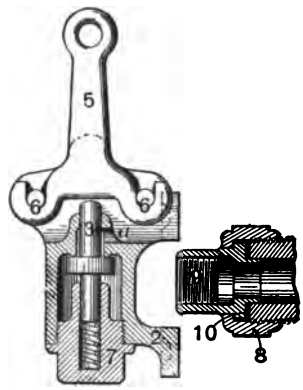


FIG. 55.

Q. What effect has this?

A. It makes a sudden reduction on the signal pipe which, as will be described later, causes the signal valve to operate and blow the signal whistle.

SIGNAL VALVE.

Q. Name the parts of the signal valve (Fig. 56).

A. 1 is the diaphragm; 4 the diaphragm stem; 5 the lower case; 7 the pivot valve; 8 the upper case; 9 the lower diaphragm plate; 10 the upper diaphragm washer; and 11 the cap.

Q. Explain the operation of the signal valve.

A. When air pressure is present in the signal pipe it is free to enter the signal valve as indicated; it passes through the small feed ports 2 and 3, thus charging chambers *B* and *A* on either side of the diaphragm 1. The ports are so proportioned that, in response to a quick reduction of signal-pipe pressure, the pressure in chamber *A* can escape faster than that in chamber *B*. As a result, the greater pressure in chamber *B* forces diaphragm 1 and diaphragm stem 4 up, causing the pivot valve to unseat; air is thus permitted to pass through ports 6, and to the signal whistle as indicated.

Q. What causes the whistle to cease sounding?

A. The same reduction that caused the signal valve to operate also caused the reducing valve to open. In response to the increase of signal-pipe pressure, due to the opening of the reducing valve, the increased pressure enters the signal valve, passes through port 2 into chamber *A* and forces diaphragm 1 to the position shown. This action seats the pivot valve and causes the blast of the whistle to cease. The pressures in chambers *A* and *B* equalize quickly through port 3, and the signal valve is again ready to respond to a reduction of signal-pipe pressure.

Q. How long must we wait before again trying to put the signal valve in operation?

A. About three seconds, long enough to be sure that the pressures in chambers *A* and *B* have equalized.

Q. Give a rule by which we can pull the whistle signal cord in the car and gain the best results.

A. When pulling the cord, make an exhaust of one

second, and then wait three seconds to allow the whistle to cease blowing and the pressures to equalize throughout the signal system before making another reduction.

Q. In pulling the signal cord, what should always be borne in mind?

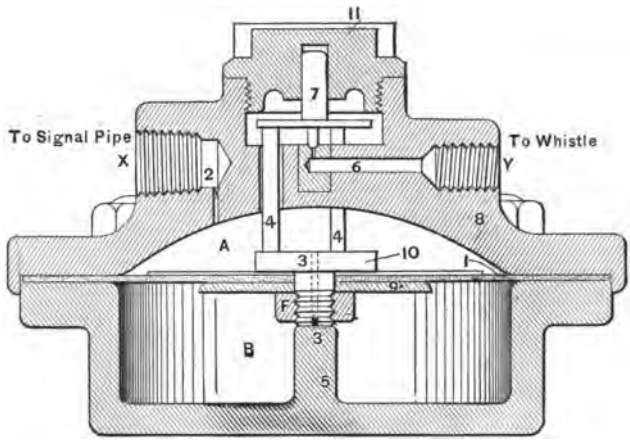


FIG. 56.

A. That it is not the amount of reduction but the suddenness that causes the whistle to blow.

Q. Fig. 59 shows the latest type of signal valve sent out by the New York Air Brake Company and is known as the 1903 model signal valve. Explain its operation.

A. A description of its operation would be but a repetition of the description of the older type of signal valve shown in Fig. 56.

Q. What is the difference in the construction of the two valves?

A. The difference in the valves consists in the method of drilling port 3; a glance at this port in the two valves clearly demonstrates this point. A projection 13 fastened to the post 5 has also been added to the later type of valve.

Q. What has been accomplished by drilling port 3 into the large port 12, and by having the port 12 fit over the pin 13?

A. The valve is made more sensitive to light, quick reductions in signal pipe pressure, without being affected by ordinary leakage; and hence gives better results on all lengths of train.

Peculiarities and Troubles of the Signal System.

Q. If no air reaches the signal pipe when an engine is coupled to a train, and we know that all cocks stand properly, what might be responsible for the trouble?

A. The reducing valve might be frozen, or the signal pipe blocked with ice. The reducing valve seldom freezes except when located outside of the cab and then only in cold weather.

Q. What is the trouble if the signal cord is pulled in the car and no air issues from the car discharge valve?

A. The cut-out cock in the saloon has been closed, the strainer into which the branch pipe connects is closed, or the seat of the valve in the car discharge valve is loose.

Q. Give conditions that would result in the air whistle not responding properly.

A. A dirty strainer in the tee under the car where the branch pipe to the car discharge valve couples to the signal pipe; ports 2 or 3 of the signal valve (Figs. 56 and 59) being stopped up; a baggy diaphragm 1 (Figs. 56 and 59), or a hole in it; the bowl of the whistle (Fig. 58) being closed with foreign matter, or the bell being improperly adjusted; a reduction that took air enough from the signal pipe

but that did not take it fast enough; or, as explained before, the reducing valve might be frozen.

Q. Why would the whistle not respond if ports 2 or 3 (Figs. 56 and 59) were closed?

A. No air could enter the signal valve if port 2 were closed and if port 3 were closed no air could reach chamber *B* beneath the diaphragm and there would be no air pressure to force the diaphragm upward when a reduction of signal-pipe pressure was made; hence, the pivot valve would not be lifted from its seat and no air could reach the whistle.

Q. Why would a baggy or stretched diaphragm 1 (Figs. 56 and 59) cause the whistle not to respond?

A. When a reduction is made in the signal pipe one is also made in chamber *A* of the signal valve, leaving the pressure in chamber *B* greater. With the diaphragm bagged the pressure in chamber *B* lifts the diaphragm, but the stem 4 is not moved.

Q. What will cause this diaphragm to bag?

A. The use of poor rubber, or oil from the pump may work through to the diaphragm and cause it to decay.

Q. What may cause a whistle to respond but once when the conductor pulls the cord twice?

A. He may have pulled the cord the second time before the whistle stopped blowing in response to the first reduction, with the result that but one long blow would be obtained; or the second reduction may have been made before the pressures in chambers *A* and *B* had become equalized. A very light reduction will sometimes produce the same result, in which case the pressure in chamber *A* is not reduced sufficiently to

permit the pressure in chamber *B* to lift the diaphragm.

Q. What will happen if dirt lodges on the seat of the small valve in the reducing valve (Fig. 57)?

A. The valve cannot close and signal-pipe pressure will equalize with that in the main reservoir.

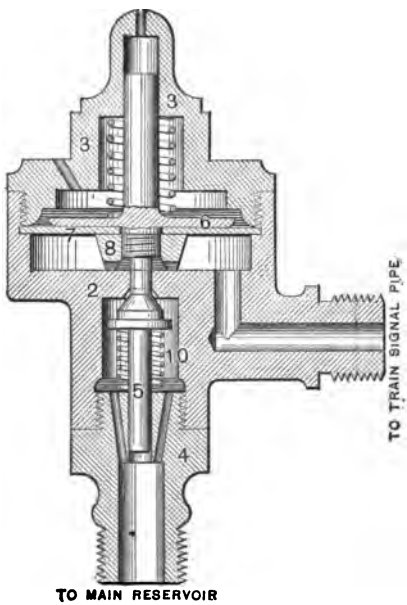


FIG. 57.

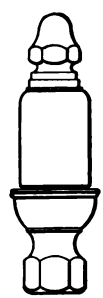


FIG. 58.

Q. What effect will this have?

A. The whistle is likely to blow, especially on a short train, when the brakes are released. On a long train the reduction would be more gradual owing to the larger volume and the blast of the whistle would

be longer. The air whistle on the engine will screech when used; there is a tendency for the whistle to blow two or three times when the signal cord is pulled but once; there will be a stronger exhaust from the car discharge valve when the signal cord is pulled; and hose are more likely to burst.

Q. Why is the whistle likely to blow when the brakes are released if there is main reservoir pressure on the whistle pipe?

A. To release brakes main reservoir pressure is put into the train pipe. This makes the pressure in the main reservoir less than that in the whistle pipe, and, on account of the dirt on the seat of the valve (Fig. 57), whistle-pipe pressure feeds back into the main reservoir. The resultant reduction of signal-pipe pressure causes a blast of the whistle.

Q. Why, with this trouble, is the whistle more likely to sound on an engine alone, when the brakes are released, than with a train?

A. With an engine alone there is but a small volume of air on the signal pipe, and this pressure feeding back into the main reservoir would cause a more sudden reduction than if the signal pipe were longer and the volume greater as on a train.

Q. Why will the air whistle on the engine screech when used?

A. Because the bell of the whistle is adjusted to operate with a 40-pound pressure instead of that which is carried on the main reservoir.

Q. If an engineer wishes to know how much pressure he has on his signal pipe, and he has no test gage, how can he determine this point?

A. Shut off the pump throttle and open the bleed cock on the main reservoir, then get up in the cab and watch the red gage hand. When the whistle blows, the red hand represents a trifle less pressure than is being carried on the signal pipe.

Q. Why does the whistle blow?

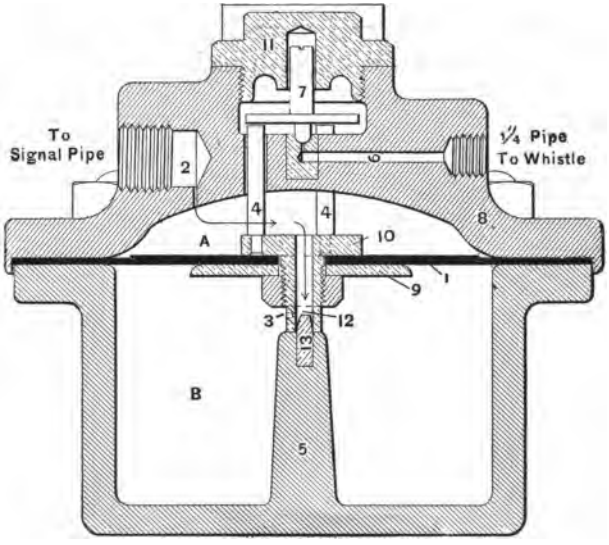


FIG. 59.

A. Because when the main reservoir is drained below the pressure in the whistle pipe, that in the signal pipe feeds back into the main reservoir, causing a reduction of signal-pipe pressure, and this usually causes the whistle to blow.

Q. What will cause a whistle to sing constantly?

A. Dirt on the seat of the pivot valve (Figs. 56 and 59).

Q. Why may jars cause a whistle to blow?

A. Oil baking on the diaphragm 1 of the signal valve makes it rigid, and a sudden jar may cause the diaphragm to lift, thus unseating the pivot valve.

Q. How may the signal-pipe pressure be increased?

A. By putting a washer under the present spring or by putting in a spring with more tension.

The Sweeney Compressor.

Q. What is the object of the Sweeney device?

A. To recharge a main reservoir quickly in descending very heavy grades when the air pressure is low.

Q. Explain the parts.

A. It consists of a pipe running from the steam chest to the main reservoir. In the pipe there is a cut-out cock, a safety valve, and a non-return check.

Q. How is it operated?

A. By turning the cut-out cock and reversing the engine when steam is shut off. The main cylinders and pistons act as compressors, and compressed air is forced into the steam chest and thence through the pipe connection to the main reservoir.

Q. What is the objection to this device?

A. It is extremely handy in case of emergency, such as low pressure or the refusal of a pump to work. The objection to it is, that smoke, gas, and heat forced into the main reservoir burn out gaskets and get the brake system very dirty.

Water Brake.

Q. What is the Water or La Chatelier Brake?

A. It is a brake by means of which the equivalent effect of reversing an engine is produced; that is, the back pressure on the pistons acts through the pins the same as when using steam.

Q. Is water actually used at the point where the work of retardation is accomplished?

A. No, it is then in the form of wet steam.

Q. Where does the water used come from?

A. It is taken from the boiler just above the crown sheet. The pressure from above being removed as soon as it leaves the boiler it flashes into wet steam. The compression to which it is subjected in the cylinders produces heat that also tends to change any water into steam.

Q. Is the lubricator shut off when the water brake is in use?

A. No, it should be kept in operation the same as when using steam.

Q. What special care should be taken when using steam after the use of the water brake has been discontinued?

A. To avoid throwing water out of the stack steam should not be used until the water has had ample time to work out. Theoretically there is no

water, but in practice a small amount is usually found.

Q. Can a water brake be used on either a simple or compound engine?

A. Yes; Fig. 60 shows its application to a simple and Figs. 61 and 62 to a compound engine.

WATER BRAKE ON SIMPLE ENGINE.

Q. What part does the water play after it takes the form of wet steam?

A. As the pistons move back and forth the wet steam in the exhaust cavities (Fig. 60) is drawn into the cylinders.

Q. How does it escape from the cylinders?

A. Through the cylinder cocks.

Q. If it were not for the wet steam being drawn into the cylinders when the engine is reversed, while using the water brake, what would happen?

A. Cinders and smoke would be drawn into the cylinders and in a short time they would be cut and ruined. The heat due to compression would also be considerable.

Q. How should an engineer proceed to put the water brake in use?

A. The cylinder cocks should first be opened and should remain open as long as the water brake is in use; the reverse lever should be moved back of the center the desired amount and the globe valve (Fig. 60) should be opened immediately.

Q. When should the water brake be put in use?

A. When the train is moving slowly.

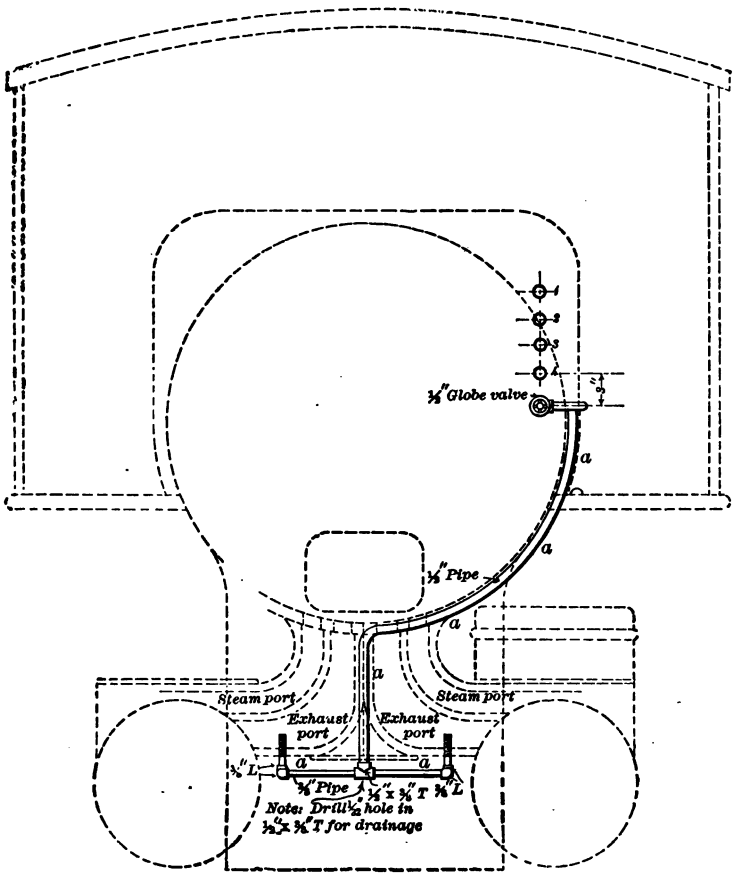


FIG. 60.—WATER BRAKE ON SIMPLE ENGINE.

Q. At how fast a speed is it practical to operate a water brake?

A. It is not generally used at speeds in excess of 14 to 20 miles per hour.

Q. How far should the reverse lever be moved back of the center?

A. This depends upon the amount of work that is required. The farther back the lever is moved the greater the power.

Q. How much should the globe valve (Fig. 60) be open to obtain the right amount of steam in the cylinders?

A. It should be adjusted until the steam issuing from the cylinder cocks is a dense white.

Q. What will be the character of escaping steam at the cylinder cocks if too little water is being used?

A. It will be a light blue in color.

Q. How can it be told if too much water is being used?

A. Water will be thrown out of the stack. This is especially noticeable if the lever is very near the center.

Q. What is the purpose of the 1-32-inch hole drilled in the 1-2 x 3-8-inch tee, as indicated (Fig. 60)?

A. To permit any condensation to escape.

Q. In erecting the piping what special care should be observed?

A. Care should be exercised to locate the ½-inch x ⅜-inch tee in the center to insure the same amount of steam reaching each cylinder; otherwise the tendency would be for one side of the locomotive to furnish more retarding power than the other.

THE BALDWIN WATER BRAKE FOR BALDWIN COMPOUNDS.

Q. Does what has been said in general concerning the water brake for a simple engine also refer to the Baldwin Water Brake for compounds?

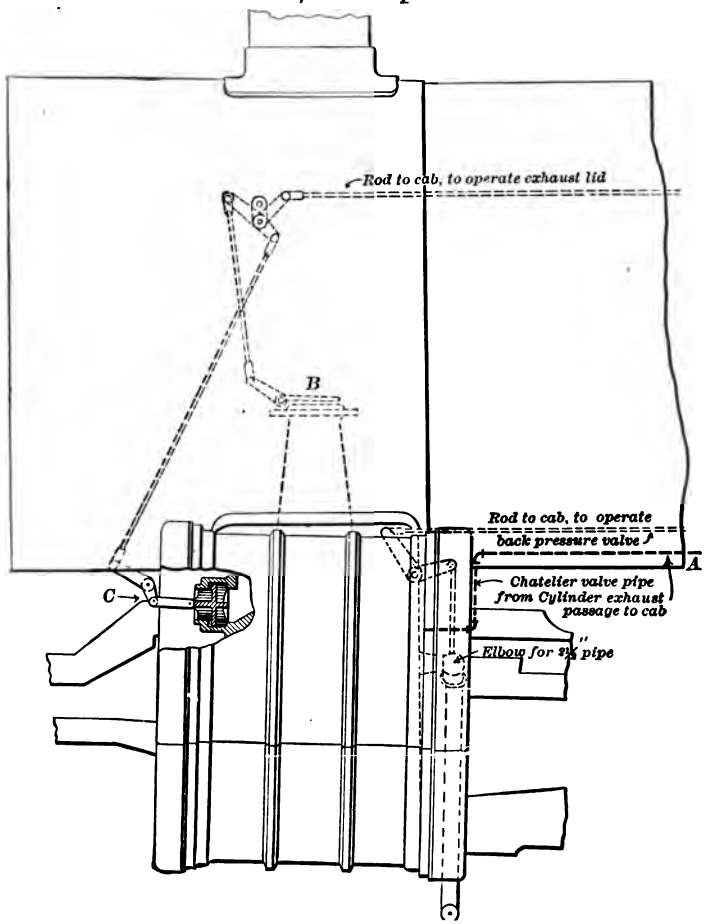


FIG. 61.—SIDE VIEW OF WATER BRAKE FOR THE BALDWIN COMPOUND.

A. Yes, and with this as with the other, the holding power is due to the engine being run reversed, the water being used as herein explained.

Q. Explain the cuts (Figs. 61 and 62) referring to the water brake for compounds.

A. Fig. 61 is a side view of the front end and Fig. 62 is an end view. When water is permitted to enter pipe *A* (Figs. 61 and 62) it finally reaches *a a*, where it enters the exhaust passages. *D* (Fig. 62) is a gate or back pressure valve, by means of which the engineer can regulate the amount of back pressure against which the pistons will operate. *E* is a safety valve located in the live steamways to permit any back pressure above a given amount to escape. *C* (Figs. 61 and 62) are air inlet valves, which when necessary permit air to enter the cylinders and prevent smoke and cinders from being drawn in. *B* (Fig. 61) is a hinged lid used to close the exhaust nozzle.

Q. How is the brake put to work?

A. The initial steps are the same as with the water brake on simple engines: Open cylinder cocks, put reverse lever in extreme backward position, and open the water valve. The exhaust nozzle lid *B* should also be closed, and the air inlet valves *C* be opened.

Q. Trace the passage of the water or steam.

A. As air enters the inlet valve *C* (Fig. 61) it mingles with the hot water and steam entering the exhaust cavities from *a a*. From here it passes by the piston valve *G* and enters the low pressure cylinder. When the movement of the piston in the low

pressure cylinder is reversed this combination of steam, water and air, excepting that which escapes at the cylinder cocks, is compressed while the other end of the cylinder is being filled. The steam being compressed passes by piston *G* and on, as indicated (Fig. 62), into the opposite end of the high-pressure

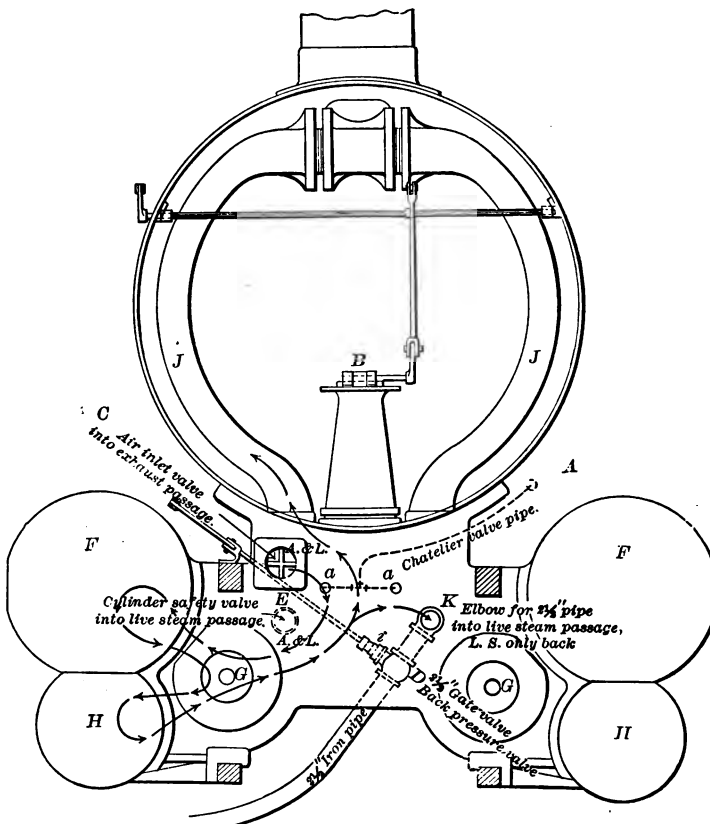


FIG. 62.—END VIEW OF WATER BRAKE FOR BALDWIN COMPOUNDS.

cylinder *H*. On the return stroke of the piston it is forced from the high-pressure cylinder by the piston valve and on into the steam pipe *J J*, where what does not escape at the back pressure valve *D* accumulates. The safety valves *E* take care of any pressure in excess of a safe amount.

Q. How is the water brake operated on a two cylinder compound of the Schenectady type?

A. Generally two water pipes are used on account of the vast difference in the sizes of the two cylinders, and the exhaust valve between the receiver and the low pressure exhaust passage is left closed while using the water brake. Otherwise the water brake is used practically the same as on a simple engine.

Train Inspection.

Q. Why is train inspection necessary?

A. To find and remedy, before trying to handle the train on a grade, any defects that would render its handling unsafe; part of the pistons may be out against the cylinder heads when the brakes are applied, the retaining valves may be poor, some brakes may not apply, auxiliaries may not charge, leaks may exist, the brakes may go into emergency when trying to make a service application, and many other defects may exist.

Q. Where should we begin to get a train ready?

A. At the rear.

Q. Is it wrong to start at the head end?

A. It would not be were the cocks not opened between the tender and cars. If the cocks were opened the air would blow through and out of a chance open cock, and a loss of time and air would result.

Q. Commencing at the rear, what should be done first?

A. The rear angle cock must be closed and the hose hung up.

Q. What harm is there in allowing the hose to drag?

A. It collects dirt and cinders, which are blown into the train and help to close strainers, and which work into the triples and cause them to wear faster.

In winter, ice getting into the hose, may block it.

Q. What should we do as we go toward the engine?

A. See that the retainer handles are turned down, hand brake released, hose coupled, and cocks turned so that the cars are cut in.

Q. How does the cock in the cross-over pipe, connecting the train pipe to the triple, usually stand when the car is cut in?

A. At right angles to the pipe. See Plate I.

Q. How should the angle cocks stand at the end of the car when cut in?

A. Parallel with the pipe.

Q. Do the angle cocks and cut-out cocks always stand as just described?

A. No; sometimes in just the reverse positions.

Q. Why is this?

A. These are cocks used with very old equipment and may be readily recognized, as they differ in shape from those now employed. If in doubt, look at the crease in the top of the plug, which always stands parallel to the opening in the valve.

Q. What should we always do before coupling the hose between the engine and cars?

A. Blow out the train pipe on the engine to get rid of dirt and water.

Q. After coupling the hose and turning the angle cocks, are we ready to look over the brakes?

A. No, not until the pump has charged the train.

Q. With a constant pressure of seventy pounds on

the train pipe, how long should it take to charge one auxiliary from zero to seventy pounds with the modern equipment?

A. About seventy seconds.

Q. How long does it take to charge a train of twenty cars?

A. This depends on the condition of the pump and the leaks in the train. If the capacity of the pump were sufficient to keep a constant train-pipe pressure of seventy pounds, twenty cars could be charged as quickly as one. This cannot be done, as twenty feed grooves take air from the train pipe faster than the pump will supply it.

Q. Who should tell when it is time for the test?

A. The engineer. He should wait until full pressure is obtained and then make a 20-pound service reduction.

Q. What should then be done?

A. One inspector should go over the train turning up the retainer handles, while the other examines piston travel and looks for leaks.

Q. What should the piston travel be?

A. If no rule exists on your road in regard to this, a piston travel between 5 and 8 inches will be found to give good satisfaction on ordinary grades.

Q. What should be done after the retainer handles are raised and the piston travel adjusted?

A. The engineer should be signaled to release, and then there should be a wait of a minute to allow the brake-cylinder pressure to reduce to what the retainer holds.

Q. What should then be done?

A. The man on deck should turn down the retainer handles. If a blow issues from the retainer when the handle is turned down, it is working properly. A strict count of those working should be kept. The man on the ground should walk along and see that the brakes release when the retainer handles are turned down.

Q. What should be done after the inspection is completed?

A. A report should be made to the engineer and conductor, giving them a knowledge of the piston travel, the number of retainers in working order, the number of cars, the number of air cars in working order, tonnage, and any general information concerning the condition of the train.

Q. In testing, would it do to open the angle cock at the rear of the train to set the brakes?

A. This is decidedly a poor practice; brakes that cannot be worked from an engine will sometimes work by opening an angle cock. If a hose lining were loose, a brakeman might apply the brakes and an engineer release them all right, while, in making the reduction from the engine, the train-pipe reduction going ahead might roll up the lining and close the hose. We want to know just how the brakes will work from the engine.

Q. If there is a leak in the hose couplings, what should be done?

A. Turn angle cocks, break the coupling, and, if the seat is bad and there is no extra hose gasket, make the seats round, if they are not so, and re-

couple. If the leak still exists, break the coupling, put a small stick back of each lug, and close the couplings on them.

Q. Why should paper never be used to make a joint?

A. It works into strainers, often causing an auxiliary to charge slowly, and it may prohibit getting quick action on this car.

Q. When inspecting a train, if we find a brake that does not apply with the rest, what should be done?

A. See that the car is cut in properly, and try the bleed cock to see that there is air in the auxiliary. If the auxiliary is charged, signal the engineer for a train-pipe reduction.

Q. If the brake applies and then leaks off gradually, without any air coming out of the triple exhaust, what is probably the trouble?

A. The air is blowing by the packing leather in the brake cylinder.

Q. How can a brake that does not apply when the reduction is made be sometimes made to work?

A. By cutting it off from the car ahead and the one behind it and opening the angle cock. The cylinder may be dirty, and setting the brake in the emergency may loosen the dirt and cause it to work properly.

Q. If the auxiliary were found to contain no air when the bleed cock was opened, what might be the trouble?

A. The feed grooves might be closed in the triple;

the strainer where the cross-over pipe joins the main train pipe, or the one where the cross-over pipe joins the triple, may be filled with dirt and scale.

Q. Is it good practice to pour oil into a hose to make a brake work?

A. Decidedly not; it may occasionally furnish temporary relief, but it will decay the rubber-seated valve and dampen the strainers, pipe, and triples so that dirt will adhere to them and render them sticky.

Q. Is a small leak, one that the pump will easily overcome, more easily managed in a long or a short train?

A. In a long train.

Q. Why?

A. Because there is a much larger volume of air in a long train pipe, and the reduction causing the brakes to leak on harder after being applied will be much slower on a long than on a short train. Frequently a leak that could not be gotten along with in a train of three of four cars, if cut in with twenty tight cars, would not be noticed.

Q. If a retainer were broken off and the pipe plugged, what would result?

A. After the engineer applied the brake, he could not release it, as the exhaust port would have been closed and permit no cylinder pressure to escape.

Q. Would it interfere with applying the brake?

A. No.

Q. If a brake sticks, what should be done?

A. Look to see that no retainer handle is up, that the hand brake is not set, and that no lever is caught.

Then signal the engineer again to release. If he is unable to release it, cut the car out and bleed it.

Q. Should a car be bled when cut out?

A. Always; a leakage of train-pipe pressure between the cut-out cock and the triple might cause the brake to apply after it was cut out if any air were left in the auxiliary.

Q. If the piston stays out on a car after we hear the air escape from the triple exhaust port, what is wrong?

A. The release spring is weak probably.

Q. Is it necessary to cut such a brake out?

A. No; the jar of the wheels against the shoes will force the piston in.

Q. If two hose couplings are frozen together, how should they be separated?

A. The ice should be thawed, or the gaskets will be torn.

Q. If a triple fails to work because it is frozen, what should be done?

A. It should be thawed and the drain plug removed in the bottom of the triple, to remove the water and avoid a repetition of the trouble.

Q. What two things would cause the brakes to go into emergency when making a gradual train-pipe reduction?

A. The port in the vent valve piston being wholly or partially closed, or a triple valve being sticky. Port *F* being partially closed is not so likely to produce the emergency application on a long train in response to a gradual service reduction.

Q. How could we find the triple causing the trouble?

A. On a train of five or six cars we can watch to see which brake grabs first and cut the car out. On a long train the brakes do not usually apply with the first reduction on the car causing the trouble, so, to find the faulty triple, have the engineer make a five-pound train-pipe reduction, find the car with the brake not set and cut it out. Then try again with all cut in to be sure that the faulty triple has been found.

Q. How would we find the faulty triple if the brakes went in quick-action with the first reduction on a long train?

A. Turn an angle cock in the middle of the train and see which half contains the trouble; continue in this manner until the trouble is located in a five-car lot; have the brakes applied and watch these five to see which brake goes into quick-action first, and cut out the defective triple.

Q. If an emergency has been used, or we find a car cut out, and, when we cut it in, a strong heavy blow issues from port M and the brakes set on the other cars at the same time cannot be released, what is the trouble?

A. The vent valve piston is stuck and thus permits air to reach the emergency piston which is forced back unseating the emergency valve, thus permitting auxiliary reservoir pressure to pass down to the check valve, unseat it, and pass into the brake cylinder. The escape of air at port *M* causes a train-pipe reduction that applies the other brakes.

Q. How can we close it?

A. Tap the triple lightly. If this does not seat the valve, turn the cut-out cock in the cross-over pipe until the blow stops. The reduction of train-pipe pressure may permit the vent valve to seat.

Q. In trying the brakes on a passenger train, how should the signal be given?

A. From the head car to apply them and from the rear car to release them; this method will assure us that the cocks through the train stand properly. On an excursion train the signal should be tried from each car of the train to be sure that the cut-out cocks in the cross-over to the discharge valve stand properly.

Q. Explain a means by which poor brakes can be detected?

A. By feeling of the wheels at the foot of a grade.

Q. What will characterize the wheels on the cars having the poor brakes?

A. They will be cold, or cooler at least than the others.

Q. What is this test called?

A. The thermal test.

Q. Would we expect to find the same degree of heat in all the wheels?

A. No; the heavier cars will have the greater braking power as compared with the light ones, and these cars would naturally have warmer wheels. This test, nevertheless, is a very valuable aid in detecting poor brakes.

Q. How would you account for it if a test were made at the top of a grade and all the brakes applied,

but some of the wheels were found to be cold when making the thermal test at the foot of the grade?

A. One of four chief causes is generally responsible for this condition: low braking power, poor packing leathers, poor retainers, or triple feed grooves in a dirty condition.

Q. What could dirty feed grooves have to do with the cool wheels if the reservoirs charged all right and the brakes applied properly at the top of the grade?

A. In the usual yard test air enough will leak past the triple-piston packing ring to charge the auxiliary so that the brakes will apply properly if the feed groove is dirty. In descending a heavy grade there are but a few seconds in which to recharge between brake applications; as a result the reservoirs on the cars are never recharged after the first application that is made on the grade, and the brakes on these cars, as developed by the thermal test, are practically useless although they did pass the first test.

Train Handling.

Q. What should we always do before coupling to a train?

A. Start the pump and be sure that everything is working properly. Do not wait to discover pump or engineer's valve defects when your train is in and ready to proceed.

Q. How should an engineer handle the brake on his engine in coupling to a train?

A. In backing onto a train, especially an empty one, he should make two or three applications of his driver and tender brakes, and leave his valve on lap when coupling to the train.

Q. Why is this done?

A. To couple to the train with reduced auxiliary pressures.

When the cocks between the engine and tender are turned, in coupling a train to an engine, the brakes are usually applied on the engine and tender on account of the reduction caused by the air flowing back into the train. If the train pipe is long and empty, the main reservoir pressure might flow back and equalize with that in the train pipe at so low a pressure that it might not be able to overcome the tank and driver auxiliary pressures so as to force these triples to release position. In this case the two brakes would be stuck, and if more cars were to be picked up, we would have to wait to pump up, or get down

and bleed these two brakes off. If we had backed onto the train with reduced auxiliary pressures on the engine and tender, we would not have met with this trouble, as the main reservoir pressure could then have raised that in the train pipe sufficiently high to have released the brakes.

Q. What should be done after getting our cars placed in the train?

A. We should wait until everything is fully charged.

Q. How can we tell when the train is charged?

A. The pump will about stop; or place the valve on lap, and if everything is charged the black hand will not fall.

Q. What should then be done?

A. A thorough test of piston travel, leaks, and retaining valves should be made before attempting to handle the train on grades.

Q. How much reduction should be made?

A. A gradual 20-pound reduction.

Q. Why is it necessary to make a test?

A. A part of the pistons may be traveling against the cylinder heads, the travel may be too short, the retainers may not be good, or there may be something wrong with a triple that would throw the whole train into emergency when the service application was desired, in which case freight might be shifted or broken, especially in a train partly equipped with air brakes.

Q. In testing brakes, from what point should they always be applied and released?

A. From the engine.

Q. How could it happen that a brakeman could turn an angle cock at the rear of the train and apply the brakes, and an engineer could release them, but that the engineer could not set them from the engine?

A. The lining of a hose might be loose, so that the engineer could throw air back into the train to release the brakes, but when a reduction was made, the air flowing in the opposite direction might roll the lining up and close the hose.

Q. Is this a common occurrence?

A. No, but it is by no means unheard of.

Q. What else should always be tested?

A. The train pipe, to see if it leaks, and how much.

Q. How should this be done?

A. By making a seven-pound reduction in service position and then placing the valve on lap. Watch the black hand, and the fall of it will show the leak on the train pipe.

Q. Will not a leak on the train pipe show if the valve is simply lapped without first applying the brakes?

A. It will in time, but not nearly so quickly as by the other way.

Q. Why not?

A. If the valve is simply lapped, the brakes are not applied, the triples are in release position, and the feed grooves connect the auxiliaries and train pipe. If there is a leak in the train pipe with the triples in release position, the air from the auxiliaries

will leak through the triple feed grooves back into the train pipe, and not only the train pipe but the auxiliary pressures will have to be reduced before the black hand on the gage will register the leak.

Q. Why is the other way quicker?

A. If the brakes are first applied and the valve then placed on lap, the feed grooves in the triples between the auxiliaries and train pipe have been closed and the leak simply has to reduce the train-pipe pressure when the black hand will register the leak. With a large volume of air a given leak will reduce the pressure much more slowly than the same leak drawing air from a smaller volume.

Q. Just as soon as a train tips over the summit of a hill, what should be done?

A. A reduction of train-pipe pressure should be made to be sure that no angle cocks have been turned and that the brakes take hold properly, also to get the use of the retainers as soon as possible.

Q. How can we tell if the angle cocks back of the tank are properly turned?

A. By the sound of the train-pipe exhaust. The more cars of air the greater the volume of air on the train pipe, and the longer the graduating valve will stay open to make a given reduction.

Q. What should be done if the brakes do not hold properly, or we know by the train-pipe exhaust that an angle cock has been closed?

A. Blow brakes before the train gets to moving fast.

Q. How much reduction should be made for the first?

A. Not less than five pounds, and after we get over fifteen cars it is better to make a seven-pound reduction. Ten pounds is the proper initial reduction to make on heavy grades where all air loaded trains are handled and where this amount of reduction will not reduce the speed too quickly.

Q. In a part air train, what would be the harm in starting with a 10-pound reduction?

A. The brakes setting hard on the air-brake cars would cause the slack on the non-air cars to run up hard, causing a jar that would be likely to damage the car or the contents, to say nothing of the effect on the crew in the caboose.

Q. Why is a light reduction liable not to set the brakes, especially on a long train?

A. Because with a large volume of train-pipe pressure, reductions are made so slowly that there is a tendency for auxiliary pressure to feed through the triple feed grooves into and equalize with that in the train pipe, in which case the triple pistons would not move; or, if they did, the air going from the auxiliary into the brake cylinder very slowly would blow through the leakage grooves past the pistons and out to the atmosphere.

Q. How much should be made for the second reduction?

A. This is governed largely by circumstances, but the best results with long trains will be gotten if no very light reductions are made. If the reduction is being made on a long train and the packing rings of some of the triples are a little loose, there is a tendency on the part of the auxiliary pressure, that

should go to the brake cylinders, to leak back into the train pipe by the packing ring.

Q. We continue our train-pipe reductions until finally our brakes are full set, that is, all the auxiliary and brake-cylinder pressures have equalized. How much reduction is usually necessary to accomplish this, if the piston travel is not over 8 inches?

A. About twenty pounds, if it is made with one reduction; but in handling a train on a grade, if we needed to get all we could, it would be permissible to make a 20-pound reduction.

Q. Give the reason for this last statement.

A. In descending a grade, we may have gone a considerable distance while we have been making a twenty-five-pound reduction. Naturally, some of the air put into the brake cylinders has escaped by the packing leathers to the atmosphere in going this distance, and making another train-pipe reduction will let more auxiliary pressure to the cylinders. Where the twenty-pound reduction was made with one reduction, the air had no time to leak away by the cylinder packing leathers.

Q. Suppose we had already made a 25-pound reduction and the packing leathers in the brake cylinders were practically tight, if we continued taking air from the train pipe, would the brakes be set any harder?

A. No.

Q. Would we lose any braking power?

A. Yes.

Q. How would we lose braking power?

A. The brake is already full set, that is, the auxiliary and brake-cylinder pressures are equal; with a further reduction of train-pipe pressure, no more auxiliary pressure can go to the cylinder; but just as soon as the auxiliary pressure is enough greater than that in the train pipe the triple-piston moves out and the port between the auxiliary reservoir remains open and, train-pipe pressure now being less than these pressures, air may feed by the triple piston packing ring and into the train pipe. This could not happen if the piston formed a good joint on the leather gasket, but these gaskets tend to dry out in time, in which case the piston does not always form a tight joint.

Q. What places should we pick out, if possible, in which to recharge?

A. Where the grade lets up a little and on curves where a train binds.

Q. To release brakes, where should the handle of the engineer's valve be placed?

A. In full release position.

Q. How long should it be left here?

A. This is governed entirely by the length of the train. If, in descending a grade, both hands on the gauge show that the train-pipe and main-reservoir pressures equalize below seventy pounds, the valve should be left in this position until both hands start to go above seventy. If the pressures equalize above seventy pounds when the valve is placed in full release, and stay there, the valve should be moved to running position as soon as the brakes are released, so as not to overcharge the auxiliaries. This repre-

sents general practice but there are exceptions in heavy grade work with heavy trains.

Q. Why, on a long train, should the valve be left in full release position until both hands start above seventy pounds?

A. A large port connects the main reservoir and train pipe in this position and a small one in running position, and we get the benefit of the excess pressure from the main reservoir in recharging; the pump works faster, and we can charge the train much more quickly, because the train-pipe pressure being higher forces air into the auxiliaries faster.

Brakes are likely to stick and wheels slide, especially on a long train, if we try to release them in running position.

Q. Why does the pump work faster?

A. Because there is less main-reservoir pressure for it to work against.

Q. Why will some brakes stick in trying to release them in running position?

A. Because the train-pipe pressure rising slowly may feed by some triple-piston packing rings, and allow auxiliary pressure to keep equal with that in the train pipe.

Q. Why will the wheels slide in this case?

A. Because the brake on this car has been left full set and the auxiliary fully recharged. A five-pound reduction will probably set this brake in full with a pressure of sixty-five pounds, and this is more than is safe, especially with a light car. If a brake once sticks it is very likely to remain stuck, as the auxiliary and brake-cylinder pressures equalize so high

that it requires a higher train-pipe pressure to release this brake, and the train-pipe pressure increasing slowly, gives the air a better chance to leak by the packing ring. A brake acting this way may be all right if handled properly.

Q. In descending a grade after getting the use of the retainers and having everything recharged, why is a five-pound reduction much more effectual than a five-pound reduction made without the use of the retainer?

A. Because in one case we are putting five pounds from the auxiliary into fifteen pounds in the cylinder, and in the other we are putting five pounds from the auxiliary into an empty cylinder, and a part of that put in blows through the leakage groove before the piston travels far enough to close it.

Q. If a 20-pound train-pipe reduction will apply a brake in full without the use of the retainer, how much reduction ought to set the brake in full after getting its use?

A. Not over fifteen pounds.

Q. If all retainers are being used, is it necessary after charging up to make a 5 or 7-pound for our first reduction?

A. Yes; some of the retainers might have been out of order, so as not to hold any air in the cylinder, and less than a five-pound reduction would not catch these brakes again.

Q. What should an engineer do, if, when he is not using the brakes, he feels them applying so as to diminish the speed of the train perceptibly?

A. He should place the handle of the engineer's valve on lap.

Q. Why?

A. Probably a hose has burst, or the conductor is using the conductor's valve. If the valve is not lapped, the main reservoir pressure will be lost, and there will be no pressure with which to release the brakes and recharge the auxiliaries.

Q. Which is less hurtful, a leak that will gradually slow a train up, or one that will simply keep the train running steadily?

A. A leak that will slow a train up is much to be preferred.

Q. Why?

A. If the leak simply runs the train steadily and the engineer allows the pressure to gradually leak away because he seems to be making a nice, smooth run, he would have a hard time stopping the train if necessity demanded it, after the pressure had leaked down to fifty pounds.

Q. Should an engineer try to make as smooth a run with air as can be done with hand brakes?

A. As a rule, no; although on some light grades a few retainers will run them smoothly. On heavy grades and long train it is necessary to slow up to recharge.

Q. What should always be done, where possible, in making train-pipe reductions?

A. Watch the gauge.

Q. What is the best method of making a water-tank or turn-table stop with an engine alone?

A. One application is best to use with an engine alone. If we find that we are stopping three or four feet short, open the throttle, and the engine can be helped along a short distance and a smoother stop be made.

Q. What happens every time you use the emergency on a turntable?

A. You strike the table a blow equal to the weight of your engine multiplied by the speed at which you are moving, and then, if the turntable breaks down, wonder why the company does not provide a decent table.

Q. In making a water-tank stop with a passenger train, how should it be done to avoid a jar to the train and passengers?

A. The stop should be made with two applications of the brake, except the grade is too steep and the pressure too low for safety.

Q. How do we handle the valve to make the first release so that the brakes will respond with the first reduction?

A. When the speed of the train has been reduced to about ten miles an hour, throw the valve handle to full release and bring it back on lap immediately.

Q. Why bring it back on lap?

A. So as not to raise the train-pipe pressure too high. The feed grooves in the triples are small, and have only three or four seconds in which to equalize the train-pipe and auxiliary pressures. If the valve is left in full release or running position, and the train-pipe pressure gets to seventy pounds and there is, say, only fifty-five pounds in the auxiliaries, the

triple pistons will not move to service position until over a 15-pound reduction of train-pipe pressure has been made. By the time we have made this amount of reduction in service position we shall have gone by the water-crane, unless we use the emergency, and that is what is usually done if the engineer is not up to date.

Q. When should brakes be released on a passenger train?

A. Just before the train stops.

Q. What should be done on a grade just heavy enough so that the train will start with the brakes released?

A. Stop the same as at a water-crane. No jar will be felt with a light application.

Q. How about a heavy grade?

A. Our stop will then depend on the grade and our pressure. Safety should be of first importance, even if the stop is a trifle rough.

Q. What makes the jar, if the brakes are not released before the train stops?

A. With the brakes set hard, the trucks are distorted, and it is the struggle of the trucks to right themselves that causes the jar; the setting of the draft springs also tend to produce rough stops if the brakes are not released until just as the train comes to a stop.

Q. Can brakes be released longer before stopping after a light or a heavy reduction?

A. After a heavy reduction, as there is more air in the cylinders to be gotten rid of, and the brakes release more slowly.

Q. What is meant by an application?

A. It covers all the time from the moment the brake is applied until it is released; three or four reductions may be made during one application.

Q. In making a stop with a freight train, when should brakes be released?

A. After the train comes to a full stop, to avoid breaking the train in two if the slack runs out hard in releasing before stopping.

The exceptions to this rule are covered in the chapter on The Combined Automatic and Straight-Air Brake.

Q. If we have stopped short with a freight train, and need to release before stopping to pull up farther, what should be done?

A. We should wait for the slack to adjust itself in the train before using steam. Even then the steam should be used very cautiously.

Q. In running passenger trains over cross-overs to get around freights, what care should be taken?

A. To do this, brakes have to be used when flagged, at the upper cross-over, lower cross-over, and usually at a station. We should charge up as much as possible after each application. Do not follow the plan of releasing and putting the valve on lap in such a case, to be sure the triples will respond quickly. They will respond quickly, but if the station is on a grade, you may not have air enough left to make the stop when you get there.

Q. What is the usual cause of trains running away?

A. Making a great many reductions without oc-

casionally charging up, or allowing the pressure to leak away, because the train is running steady, and then when we get ready to recharge, not having enough air left to slow up the train.

Q. On a fast passenger run, how may time be saved in using the brake?

A. By waiting longer before applying the brakes and then making a reduction of about ten pounds at the start.

Q. Will this not jar the passengers?

A. Not when going fast. Passenger trains consist mostly of continuous platform cars, and there is very little slack to run up. A 10-pound reduction made with a train moving ten miles an hour would produce a very unpleasant sensation to passengers, where at forty miles an hour it would not be noticed. This is explained in the subject HIGH-SPEED BRAKE.

Q. Should brakes be tested in taking on cars?

A. Always; to be sure that the brakes on these cars work properly, and that the brakes back of them can be applied and released through them.

Q. When all retainers on a train are not necessary, how should they be used?

A. At the head end if the grade is short; otherwise change them about, using them on every other car, so as not to overheat any wheels.

Q. If the brakes are applied and the engineer wishes to release and drift two or three hundred feet before stopping, what should be done?

A. Enough retainers should be put in operation to keep the slack bunched; the straight-air may be

used for this purpose if it forms a part of the engine and tender equipment.

Q. When should hand brakes be used?

A. On the rear of a part air train when backing it into a siding, or, if it stands on a knoll, to keep the slack from running back.

Q. Should hand brakes and air brakes be used together on the same car?

A. This is a risky practice. If the two brakes work together, we are very likely to slide wheels, and if they work in opposition, there is danger of a brakeman being thrown from the car, and the hand brake being applied will take up the slack in the brake rigging, so that the piston cannot get by the leakage groove.

Q. If hand brakes be used back of the air when there are not enough air brakes to control the train, what is likely to happen?

A. This is likely to produce a bad effect when the air brakes are released. If the retainers are poor and allow the slack to run out, the train may be broken in two.

Q. If hand brakes are to be used with the air, where should they be applied?

A. Next to the air.

Q. Should driver brakes be cut in when descending a heavy grade?

A. Always, or so much more work is thrown on the car brakes. The use of a water brake would, of course, be an exception to this rule.

Q. If cut in all the time on heavy grades would the tires not become overheated?

A. In heavy grade work the piping is usually so arranged that a cock can be closed between the triple valve and brake cylinder, or a pipe from the brake cylinder is run into the cab and a cock attached to same. In either case the proper manipulation of these valves will prevent overheating of tires.

Q. If an air-brake train should be stalled on a grade, should part of the train be left with air brakes to hold them until the engine comes back?

A. No; the air brakes should be released one at a time, and the hand brakes applied. If left with the air holding them, the air might leak off and allow the train to run away.

Q. When brakes are full set, the long travel brakes are easier to release. They may be released and leave the short travel brakes applied. Is this good practice in holding trains?

A. No; it is very bad practice. A train may be broken in two in this way, and generally bad results may follow.

Q. If brakes stick and will not release by placing the valve in full release, what should be done?

A. Make a full service reduction and then, with a full excess pressure, throw to full release. If a release from the engine is possible, this will accomplish it.

Q. What harm is there in pulling hose apart instead of uncoupling them?

A. The couplings are likely to be sprung so that

they cannot be coupled again, and the train pipe is likely to be torn from the car or engine.

Q. What is the trouble, when there is a leak on the train pipe, if the engine is alone, but coupled to tight cars, the leak does not show?

A. The leak is in the angle cock at the rear of the tender. When coupled to a train, the leak is not noticed as the cock is open. With the engine alone the cock leaking allows air to pass out of the hose to the atmosphere.

Q. In double heading, which engine should handle the brakes?

A. The lead engine.

Q. What should the second engineer do?

A. Turn the cut-out cock under his valve, and under no circumstance, unless told or signaled to, should he cut in and interfere with the work of the lead engine.

Q. If the pusher engine has no cut-out cock, what should be done?

A. The valve should be placed on lap.

Q. In case of emergency, when it is necessary for us to leave the engine, what should be done?

A. Throw the engineer's valve to full emergency position and leave it there. In our hurry, if we tried to lap the valve, we might get it into running position and release the brakes.

Q. If the emergency position of the brake valve were used and the handle was brought back to lap position quickly, what might result?

A. There might be two or three cars cut out, a

couple of plain triples, a contracted passage, or a couple of cars that would not go into quick-action on account of dirty strainers. If these cars were together, they would not help to carry the quick-action back. Generally a quick-action triple will not send a quick reduction through five cars which are cut out. In this case, if the engineer's valve had been lapped too quickly, the surge of air ahead from the rear end would release the head brakes, and all we would have would be a very light service reduction on the cars back of those cut out. If we leave the engineer's valve in emergency position long enough, we could at least get the full service application on these cars, and the emergency on those ahead of the cars cut out.

Q. Should the engine be reversed when the driver brakes are applied, if we wish to stop quickly?

A. No; the following test made by Mr. Thomas, Assistant General Manager of the N. C. and St. L., clearly demonstrates that the air brake used alone is better than the brakes with the reverse lever, or than the reverse lever alone.

The results of these tests were published in the *'95 Air-Brake Proceedings,* and are given on the pages following.

The conditions of the test were as follows:

Driving brake power, seventy per cent; tender, one hundred per cent; N. C. and St. L. coaches, ninety per cent; Pullman sleeper, forty to one hundred and one per cent.

Boyer speed recorder was used and tests were made: first, brakes applied; second, engine reversed; third, sand lever opened. Track was level, in best possible condition, and all circumstances favorable.

TABLE.

No.	BRAKES USED.	CONDITION OF TRAIN.	SPEED.	SAND.	TOTAL NO. OF STOPS MADE.	MAXIMUM LENGTH OF STOPS.	MINIMUM LENGTH OF STOPS.	AVERAGE STOP IN FEET.	TIME IN SECS.	WHEELS SLID.	FLAT SPOTS.
1	Driver and tender brakes.....	Engine and tender.	30	No.	9	280	240	254	11	No.	No.
2	Driver brake alone	" "	30	"	2	438	387	412	18	"	"
3	Tender " "	" "	30	"	7	604	458	538	28	"	"
4	No brakes, engine reversed.....	" "	30	"	3	464	426	450	20	Locked and revolved backwards.	"
5	Driver and tender brakes and engine reversed....	" "	30	"	4	290	245	276	12	Yes.	2¼ in.
6	No brakes and engine "plugged"	" " ...	30	"	2	540	505	522	25	Locked and revolved backwards.	No.
7	Driver and tender brakes. ...	" "	30	Abundance	1	260	260	260	11	No.	"
8	No brakes and engine reversed.	" "	30	"	1	280	280	280	12	"	"
9	" " " " "plugged"	" "	30	"	1	265	265	265	11	"	"
10	Driver and tender brakes and engine reversed	" "	30	No fresh sand	4	177	140	158	9	"	"
11	Driver and tender brakes, with engine "plugged"	" "	30	"	1	177	177	177	9	"	"
12	Driver and tender brakes.	" "	20	No.	1	111	111	111	8	"	"
13	No brakes and engine reversed.	" "	20	"	1	161	161	161	9	"	"
14	Driver and tender brakes.	" "	20	Yes.	1	90	90	90	6	"	"
15	" " " "	" "	40	No.	1	532	532	532	25	"	"
16	No brakes, engine reversed. ...	" "	40	"	2	861	830	840	32	Locked and revolved backwards.	"

TABLE.—CONTINUED.

No.	BRAKES USED.	CONDITION OF TRAIN.	SPEED.	SAND.	TOTAL NO. OF STOPS MADE.	MAXIMUM LENGTH OF STOPS.	MINIMUM LENGTH OF STOPS.	AVERAGE STOP IN FEET.	TIME IN SECS.	WHEELS SLID.	FLAT SPOTS.
17	Driver and tender brakes.....	Engine and tender.....	40	Yes.	1	475	475	475	20	No.	No.
18	All brakes cut in.....	Engine, tender and 5 N. C. & St. Louis coaches.....	30	No.	8	271	260	258	11	"	"
19	" " "	Engine, tender and 5 N. C. & St. Louis coaches.....	30	Yes.	1	250	250	250	11	"	"
20	" " " engine reversed.	Engine, tender and 5 N. C. & St. Louis coaches.....	30	"	7	335	199	265	11	Yes.	3 in.
21	" " "	Engine, tender and 5 N. C. & St. Louis coaches.....	40	No.	4	500	400	474	19	No.	No.
22	" " "	Engine, tender and 5 N. C. & St. Louis coaches.....	40	Abundance.	1	475	475	475	19	"	"
23	" " " engine reversed.	Engine, tender and 5 N. C. & St. Louis coaches.....	40	Yes.	1	542	542	542	23	Yes.	4 in.
24	" " "	Engine, tender, 5 N. C. & St. L. coaches and 4 Pullmans....	30	No	1	327	327	327	14	No.	No.
25	" " "	Engine, tender, 5 N. C. & St. L. coaches and 4 Pullmans	35	"	1	465	465	465	19	"	"
26	" " "	Engine, tender, 5 N. C. & St. L. coaches and 4 Pullmans ...	40	"	2	575	575	575	25	"	"
27	" " "	Engine, tender & 4 Pullman sleepers.....	30	"	1	367	367	367	14	"	"
28	" " "	Engine, tender & 4 Pullman sleepers.....	40	"	1	702	702	702	26	"	"
29	* " " " engine reversed.	Engine, tender and 5 N. C. coaches.....	30	Yes.	9	375	218	350	13	Yes.	2¾ in.
30	† " " " " "	Engine, tender and 5 N. C. coaches	30	"	1	325	325	325	13	No.	No.
31	* " " " " "	Engine, tender and 5 N. C. coaches	30	"	1	375	375	375	14	Yes.	3 in.
32	Pullman sleeper "kicked.".....	.....	30	No.	1	416	416	416	18	No.	No.
33	N. C. and St. L. coach "kicked."	.....	30	"	1	202	202	202	10	"	"

* Unexpected Emergencies.

† Expected Emergency.

From the record of tests the following valuable information was derived:

First. Best stops are made with braking power not quite strong enough to skid wheels.

Second. Length of stop is the same in reversing the engine whether cylinder cocks are open or closed.

Third. The wheels did not lock rigidly when the engine was reversed without the brakes being used.

Fourth. The tests demonstrated that the brakes used alone are better than with the engine being reversed. The stop is quicker, and there are no flat spots obtained.

Fifth. Enough sand is much better than too much.

Sixth. Sand should be used before wheels start skidding, as its use will not start the wheels revolving when once skidding; it will simply increase the flat spots.

Seventh. Sand being used on a straight track, the drivers did not lock when the engine was reversed, but on a curve they would. On a curve the engine rocks, and sand is not so likely to strike the rail.

Eighth. In expected emergencies, the drivers did not lock when sand was used before brakes were applied and engine reversed, but it took so long to get the sand running first that, in the end, the stop was not made as quickly as with unexpected emergencies where the engine was not reversed.

Ninth. The unexpected emergencies are the ones that bear the most weight, as expected emergencies are practically unheard of.

Cam Brake.

The following simple rule to find the braking power developed by a cam brake is given by Mr. H. A. Wahlert:

Take two wires and place them between the brake shoe and the wheel, one at the top and one at the bottom of the shoe. Apply the brakes fully, and then measure the piston travel. Now release the brakes, recharge, and then apply fully again. Measure the piston travel again, and note how much more it has increased. Divide the additional travel had upon removing the wires by the thickness of the wire, and multiply this by the value of the cylinder. The result is the braking power on each brake shoe.

Four times this power is the total braking power developed on all four shoes.

EXAMPLE.

Thickness of wires, $\frac{1}{8}$ inch.

Piston travel, with wires inserted according to rule, 3 inches.

Piston travel, with wires removed, $3\frac{1}{2}$ inches.

Value of 8-inch cylinder, 2,500 pounds.

$3\frac{1}{2}$ inches $-$ 3 inches $= \frac{1}{2}$ inch.

$\frac{1}{2}$ inch $\div \frac{1}{8}$ inch $= 4$.

2,500 pounds $\times$ 4 $=$ 10,000 pounds on each brake shoe.

10,000 pounds $\times$ 4 $=$ 40,000 pounds on all four brake shoes.

Outside Equalized Brake Leverage.

Q. How do you find the braking power on an engine equipped with the outside equalized brake as shown in Fig. 63?

A. Multiply the cylinder value, or total push on the piston, by the long lever arm, and divide this product by the short lever arm. This result multiplied by 2 gives the total braking power.

Q. With the long lever arm 25 inches long and the short arm 5, what braking power would we have, using 12-inch cylinders?

A. 56,000 pounds.

Thus:

$$5{,}600 \times 25 = 140{,}000$$
$$140{,}000 \div 5 = 28{,}000$$
$$28{,}000 \times 2 = 56{,}000$$

Q. If any different design of rigging were used than that shown in the sketch, how could the braking power be figured?

A. First find the power exerted at the bottom of the rocker shaft and use this in connection with the cuts illustrating the different classes of levers as contained in the subject of Brake Leverage.

Q. What per cent of the total weight of drivers is used as braking power with driver brakes?

A. Seventy-five per cent of the engine's weight on the drivers when ready for the road for a simple engine and from 55 to 60 per cent for compounds.

Q. What braking power should be used on an engine whose weight on drivers is 90,666 pounds?

A. $90{,}666 \times .75 = 68{,}000$ pounds.

Q. What weight should be on the drivers for an engine to have 68,000 pounds braking power?

A. $68{,}000 \div .75 = 90{,}666$ pounds.

Q. How should the holes be spaced in levers A and D on an engine having two pairs of drivers, to give an equal braking power on each wheel?

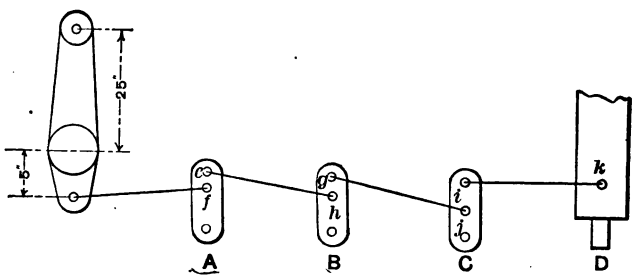


FIG. 63.—OUTSIDE EQUALIZED BRAKE.

A. The middle hole in *A* should be equidistant from the two outside ones. The hole in the lever at *D* should be so as to have the connection attached at *k* stand about parallel with the track. The corresponding hole *k* at the other end of the lever *D* must be placed the same distance from the other end.

Q. How should the holes be spaced in levers A, B, and D, if on a mogul or engine having three pairs of drivers?

A. The distance *e*, lever *A*, should be one-half the distance *f*. The distance *g*, lever *B*, should be equal

to *h*. The hole *k*, lever *D*, should be the same as on an engine having two pairs of drivers.

Q. How should the holes in the levers A, B, C, and D be spaced on a consolidation or engine with four pairs of drivers?

A. The distance *e* in lever *A* should be one-third of *f*. The distance *g*, lever *B*, should be one-half of *h*. The distance *i*, lever *C*, should be equal to *j*. The hole *k* in lever *D* should be the same as with an engine having two or three pairs of drivers.

Lubricants.

Q. What lubricants should be used in the different brake apparatus?

A. Steam cylinder of pump—Valve oil.
Air cylinder of pump—Valve oil.
Brake valve—High-grade machine oil.
Triple valve and high-speed reducing valve—High-grade mineral oil.
Brake cylinder—A light grease that will not flow in summer or become thick in winter.

A great many people seem to think that any kind of a lubricant is good enough for the air brake apparatus; if a little more attention were given to this part of the air-brake subject much better and more satisfactory results would be obtained and the life of the apparatus would be increased correspondingly.

On the long trains of to-day it is especially important to use the kind of air cylinder lubrication recommended since the pump is called upon to do much more work than formerly, and in order to make the conditions as favorable as possible a good quality of oil and a larger amount of it must be used. The practice of using engine oil in a pump can not be condemned too strongly as the flash test of this oil is low and will not lubricate properly where subjected to the heat that exists in the air cylinder of the pump. Instead of acting as a lubricant, it burns, and the burnt oil tends to make the pump wear faster and it also clogs the air passages.

Piping.

Q. What should be done in preparing pipe for use?

A. After bending the pipe it should be blown out with steam to get rid of scale and dirt. If there is no steam at hand, air should be used. Under no consideration should pipe be used without first being cleaned. All fins should be carefully removed to prevent their working loose and clogging strainers.

Q. What should be done to the pipe while it is being blown out?

A. It should be tapped lightly to loosen the scale.

Q. What size pipe should be used in the different parts of the system?

A. The sizes given in the air-brake catalogues are correct and should be strictly adhered to.

Q. When using red lead on pipe how should it be applied?

A. Always on the outside of the thread to be screwed in, as in this way the red lead will not get inside the pipe.

Q. In applying piping, what should be avoided?

A. No sags should be allowed in which water might collect; where practicable, gentle bends should be substituted for elbows, and very short bends should be avoided.

Q. Why are elbows or short bends undesirable?

A. The friction caused by them retards the flow of air when a sudden reduction is desired in emergency.

Q. Could pipe work be so crooked and elbows so numerous on an engine that a sufficiently quick reduction to cause emergency would not go through an engine?

A. Yes; this has been found so on engines, but the trouble was remedied when the number of elbows and bends was reduced.

Q. How should pipe work be secured?

A. By clamps that will hold the pipe rigidly in place so as not to allow the pipes to be moved, holes to be chafed in them, or any vibration to exist.

Q. After the pipe work is applied, what should be done?

A. It should be thoroughly tested under full pressure, and the leaks detected by the use of soapsuds.

Q. After the pipe is tested, what should be done?

A. It should be painted with a rust-proof paint and one, if posssible, that will not be affected by salt water dripping from refrigerator cars or by the acid in soft coal.

Q. Why is larger pipe used on freight than on passenger cars?

A. Because on a long freight train a sudden reduction will travel through the large pipe more quickly, as the larger the pipe the less the friction exerted to the passage of the air.

Q. Is there any other reason?

A. Yes; in emergency, with quick-action triples, air from the train pipe is put into the brake cylinder; a freight car being shorter than a passenger car, the larger pipe makes the volume of air in the train pipe more nearly equal to that in the smaller pipe used on the longer passenger cars.

Air-Brake Recording Gages.

Q. What is an air-brake recording gage?

A. It is a mechanism by means of which lines are traced upon a chart. An examination of these lines will tell exactly how the brakes have been manipulated by the engineer.

Q. What causes the lines to be traced upon the chart?

A. The contrivance has an arm containing a pen which is raised or lowered as the pressure fluctuates in the place to which the gage is piped. As the pen and chart move, a line is traced showing the variation of the pressure.

Q. What causes the chart to move?

A. It is connected with a clock movement, by the adjustment of which the movement of the chart is controlled.

Q. To what else is the recording gage similar?

A. To a steam indicator; but in that case steam instead of air causes the pen to rise or lower as the pressure changes, and the movement of the main steam piston imparts a movement to the indicator drum upon which paper is fastened, and upon which a line is traced by a pen or pencil.

Q. To what part of the air brake system is the recording gage piped?

A. It may be piped to the train pipe, the auxiliary reservoir, or the brake cylinder. On a passenger train the gage is usually placed at the rear of the train, while on a freight train it is placed in the caboose.

Q. Which of these places is preferred?

A. The train pipe. So connected, the chart shows the fluctuation of pressure when the brakes are applied and released, and the exact habits of the engineer are shown.

Q. How many forms of recording gages are there?

A. Two; a revolving gage, the chart of which is shown in Fig. 64, and a horizontal gage, a chart from which is shown in Fig. 65.

Q. From the record made by a recording gage, what may be ascertained?

A. The amount of train-pipe pressure carried; the correctness of the air gage; the method employed by the engineer in the application and release of the brakes; the position of the brake valve handle in releasing brakes and recharging the train; it is a valuable adjunct in finding the cause of air brake wrecks or "failures"; shows if the air brake instruction of the road is lived up to; shows how long it takes to recharge with the different main reservoirs and pumps on the different engines; it is a valuable aid in discovering the cause of slid flat wheels; it increases the interest of the engineers in air brake matters, as their record and skill are shown by the lines on the chart; besides these things, a great deal of kindred information may be gleaned by a careful study of the charts.

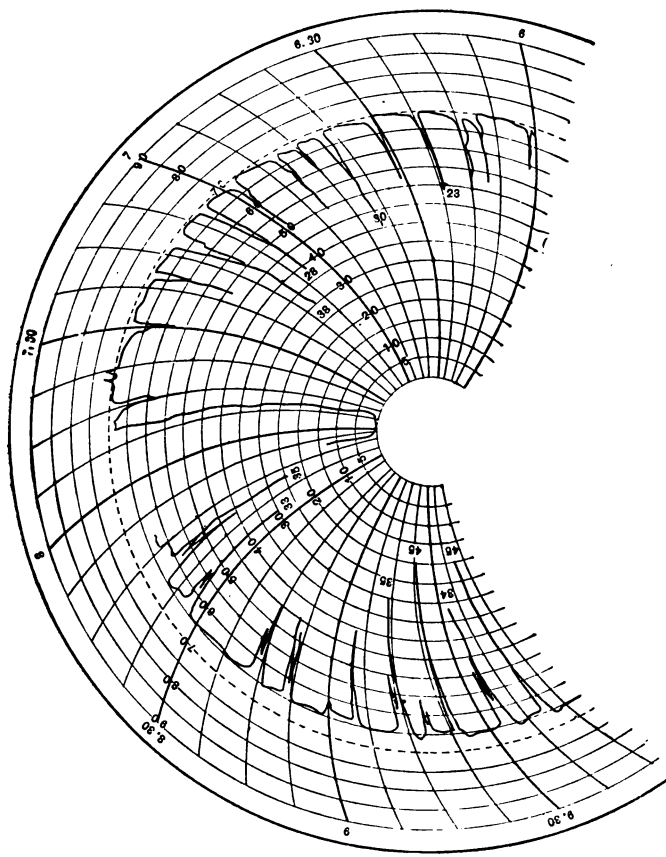


FIG. 64.—REVOLVING RECORDING GAGE.

Q. At what speed do these charts usually move?

A. From two and one-quarter to four and one-half inches an hour, as desired. Horizontal charts have been used at as high a speed as three feet an hour. The speed can be adjusted by means of the clock.

FIG 65.—HORIZONTAL RECORDING GAGE.

Q. Is there any advantage gained from a slow or fast movement of the paper?

A. A slow movement condenses the record and does not require so large a chart, while a fast movement uses a longer chart, but shows a greater corresponding amount of detail. If a slow movement is used, and the detail is desired at any particular point, such as a water crane or milk depot, the speed of the paper may be adjusted as desired.

In Fig. 64, the broken line shows the path the pen would trace if there was a constant pressure of 70 pounds. No pressure is represented by the circumference of the small circle.

The figures at the top are a time reference, and the figures up and down refer to the amount of pressure.

The distance between the lines running up and down represents distance traveled by the train. The chart (Fig. 64) shows two records

on the same run made by two different men. A study of the two shows several points of interest.

The best work shows on the card to the right; the card at the left shows that the train-pipe governor was not adjusted properly for a 70-pound train-pipe pressure, or else the gage was wrong; the card at the right shows three station stops where the engineer made more than a 20-pound train-pipe reduction, while the card at the left shows the same thing at six stations, and at almost every station the stop was made by two applications of the brake. The amount of reduction points very strongly to the use of the emergency.

Fig. 65 shows a record taken from a horizontal recording gage.

The horizontal lines represent pressure as indicated, and the length of the paper shows the distance.

The card shows that a train-pipe pressure of 72 pounds was used, and that the engineer was in the habit of making too heavy train-pipe reductions.

In one place the train-pipe pressure was reduced to 18 pounds, another to 15, another to 8 pounds, and in one case all air was taken from the train line. The two cases of heavy reduction at the left of the record point strongly to the use of the emergency position of the brake valve.

In two places at the right the card shows that in two places the engineer released to recharge, but evidently did not calculate properly, as both times he started to apply the brakes when the train pipe was only charged to 60 pounds. The pressure in the auxiliaries was undoubtedly even somewhat less than this.

A Few Practical Formulae and Rules for Air-Brake Inspectors.

(1) $\frac{\text{Braking power}}{\text{Cylinder value}} = \text{Total leverage.}$

(2) $\frac{\text{1-inch piston travel}}{\text{Total leverage}} = \text{Shoe movement for 1 inch of piston travel.}$

(3) $\frac{\text{Shoe wear}}{\text{Shoe movement for 1 inch of piston travel}} = \text{Total increase of piston travel to wear out a set of shoes.}$

ILLUSTRATION OF ABOVE FORMULAE.

Assume:

Weight of car = 40,000 pounds; it is to be braked at ninety per cent of its weight; 10-inch cylinder used; shoes 1½ inches thick.

Ninety per cent of 40,000 = 36,000 pounds. The cylinder valve, or push on the piston, of a 10-inch cylinder, when the brake is set in emergency with a quick-action triple, is 4,700 pounds.

Substituting values in the equations:

$$(1)\ \frac{36{,}000}{4{,}700} = 7.66$$

7.66 is the total leverage; that is, the push of 4,700 pounds on the piston must be multiplied 7.66 times to give the proper braking power.

$$(2)\ \frac{1''}{7.66} = .13'' \text{ or } \frac{13}{100}$$

13-100 of an inch is the distance that the brake shoes will move for each inch that the piston travels.

$$(3)\ \frac{1\frac{1}{2}}{.13} \text{ or } \frac{1.5}{.13} = 11.5 \text{ or } 11\frac{1}{2}$$

11½ inches is the distance the piston travel would have to increase to wear out a set of shoes 1½ inches thick.

To find the area of a piston:

Multiply the diameter of the piston by itself, and this product by the decimal .7854.

Example:

What is the area of an 8-inch piston?

$8'' \times 8 = 64$ sq. in.

64 sq. in. $\times$ .7854 = 50.26 sq. in.

50.26 square inches is the area of the piston; that is, the number of square inches in a circle 8 inches in diameter.

To find the volume or cubical contents of a cylinder:

Multiply the diameter of the cylinder by itself, this product by the decimal .7854, and this product by the length of the cylinder.

Example:

What is the volume of a cylinder 8 inches in diameter and one foot long?

$8'' \times 8 = 64$ sq. in.

64 sq. in. $\times$ .7854 = 50.26 sq. in.

50.26 sq. in. $\times$ 12 = 603.12 cu. in.

To find the pressure at which an auxiliary and brake cylinder will equalize with a full service application of the brake using an initial pressure of seventy pounds in the train pipe and auxiliary:

Multiply the capacity of the auxiliary in cubic inches by eighty-five pounds (seventy pounds train-pipe pressure plus fifteen pounds atmospheric pressure), and divide the product by the combined capacity of the auxiliary and brake cylinder. The quotient will be, approximately, the pressure plus fifteen pounds atmospheric pressure. This is not absolutely correct, as it does not take into account the clearance in the cylinder back of the piston with the brake released. This usually corresponds to about 1 inch of piston travel.

Example:

Capacity of freight auxiliary reservoir = 1.625 cu. in.

Capacity of 8-inch brake cylinder with 8-inch piston travel = 400 cu. in.

$1{,}625 \times 85 = 138{,}125$. $138{,}125 \div (1{,}625 + 400) = 68$ 68 lbs.—15 = 53 lbs.

Fifty-three pounds is the pressure obtained in the auxiliary and brake cylinder with the brake full set in service.

The formulæ given below will be found convenient with which to find either the proper width of a lever to withstand a given strain, or to ascertain the fiber strain on a lever.

R = Fiber strain.

l = Distance from point power is applied to center of pin at point for which dimension or amount of fiber strain is desired.

b = Equals thickness of lever.
d = Width of lever.

No allowance is made for the metal taken out of the lever for the pin holes, as the removal of metal has no practical weakening effect, same being so close to the central axis.

In general railroad air-brake practice, from 18,000 to 20,000 is considered a safe fiber strain.

$$R = \frac{6\,P}{b\,d^2}$$

$$d = \sqrt{\frac{6\,Pl}{R\,b}}$$

Example:

To find the fiber strain at the middle hole of a lever 24 inches between the push-rod and outside holes, middle hole 12 inches from push-rod hole, width of lever 4.336 inches at middle hole, lever 1 inch thick, 10-inch cylinder used, and a maximum pressure of 60 pounds obtained in the cylinder, giving a total power of about 4,700 pounds acting on the piston.

$$R = \frac{6\,Pl}{b\,d^2} \quad R = \frac{6 \times 4700 \times 12}{1 \times 4.336 \times 4.336} \text{ or } R = 18{,}000 \text{ pounds.}$$

Example:

Under the same conditions as the preceding example find the proper width of the lever at the middle hole, permitting of a maximum fiber strain of 18,000 pounds.

$$d = \sqrt{\frac{6\,Pl}{R\,b}} \text{ or } d = \sqrt{\frac{6 \times 4700 \times 12}{18{,}000 \times 1}} \text{ or}$$

$$d = \sqrt{18.8} \text{ or } d = 4.336 \text{ inches.}$$

Width of lever should be 4.336 inches.

To reduce stops at different speeds to an equivalent stop at the same speeds, all other conditions being equal.

Rule: Multiply the known distance by the square of the speed for which proportionate distance is desired, and divide the product by the square of the speed at which known stop was made.

This rule is only practical with speeds which are not more than three miles above or below the speed for which proportionate stop is to be calculated.

Example:

If a stop at 58 miles per hour is made in 1,600 feet, and one at 62 miles per hour in 1,800 feet, in what distance would each of these stops have been made at a speed of 60 miles per hour?

Square of 58 miles = 3,364.

Square of 62 miles = 3,844.

Square of 60 miles = 3,600.

$$\frac{1{,}600 \times 3{,}600}{3{,}364} = 1{,}712.$$

$$\frac{1{,}800 \times 3{,}600}{3{,}844} = 1{,}691.$$

In the first case the stop at 60 miles per hour would have been made 1,712 feet, while in the latter it would have taken 1,691 feet.

Braking Power and Leverage.

Q. What is meant by braking power?

A. The force applied by the shoes against the wheels to stop the motion of a car.

Q. What is meant by the percentage of braking power?

A. The total brake-shoe pressure as compared to the light weight of the car. The percentage is found by dividing the total braking power by the light weight of a car.

Q. What per cent of the weight of a car is used as braking power on a freight car?

A. The New York Air Brake Company recommends the use of eighty-five per cent braking power figured on a brake-cylinder pressure of 60 pounds, or practically seventy per cent figured with a cylinder pressure of 50 pounds which is obtained with a New York Triple Valve in either a service or an emergency application of the brake.

Q. On a passenger car?

A. From eighty-five to ninety per cent of the light weight of the car, figuring the brake-cylinder pressure as being sixty pounds. This gives an actual braking power in service or emergency of about seventy-five per cent.

Q. Can these percentages be used if the car has

two six-wheel trucks, and only two pairs of wheels on each car are braked?

A. No; the percentages given refer to a certain per cent of the total weight on the rail of the braked wheels.

Q. What per cent of braking power is used in designing driver brakes?

A. Usually seventy-five per cent or three-fourths of the weight on the drivers when the engine is ready for the road.

Q. What per cent of braking power is used on tenders?

A. Usually one hundred per cent, except on mountainous roads where the braking power used is less owing to the fact that a heavy grade causes considerable weight to shift from one truck to the other and the water is higher on the low end of the tender. The shifting of the weight tends to cause the trail wheels to slide.

Q. Why is a larger per cent of braking power used on tenders than on engines or cars?

A. Because tenders are practically always loaded.

Q. How are these percentages determined on as safe?

A. By actual tests in the different kinds of service.

Q. What brake-cylinder pressure is used in figuring the braking power with the different sizes of cylinders with the New York Brake?

A. Sixty pounds with quick-action and fifty pounds with plain triple valves.

Q. How do we calculate the force acting on the push rod due to the pressure in the cylinder acting on the piston?

A. Multiply the diameter of the piston by itself; the product by the decimal .7854, and this last product by the pressure in the brake cylinder.

Q. What force would act on the push rod of an 8-inch cylinder using a quick-action triple?

A. $8 \times 8 \times .7854 \times 50 = 2{,}513$, usually figured as 2,500 pounds.

Q. With a plain triple?

A. The same as with a quick-action triple valve.

Q. Explain the difference in the percentage of braking power of a freight car light, and the same car when loaded to its full capacity.

A. Suppose a freight car to be braked at seventy per cent of its light weight.

If the light weight of the car is 25,000 pounds, it is given 17,500 pounds braking power. If the capacity of the car is 60,000 pounds, when loaded to its full capacity the total weight of the car and contents is 25,000 + 60,000, or 85,000 pounds, but we have only the brake-shoe pressure to stop the car loaded that is used when it is light. We get about 50 pounds pressure in the brake cylinder and have seventy per cent braking power with a light car, but with the car loaded, when the brakes are fully applied, the braking power is only twenty and one-half per cent of the total weight of this car.

Q. How is the percentage of braking power of a passenger car affected by its load?

A. Not very much, since the additional weight when loaded is comparatively small.

Q. What forces are figured as acting at the push rod with the different sized cylinders, the cylinder pressure being taken as fifty and as sixty pounds?

A. At fifty pounds:

6 in.	8 in.	10 in.	12 in.	14 in.
1,400 lbs.	2,500 lbs.	4,000 lbs.	5,600 lbs.	7,700 lbs.

At sixty pounds:

1,700	3,000	4,700	6,800	9,200

By using the following cuts and formulæ, the braking power on a car with any kind of leverage may be figured.

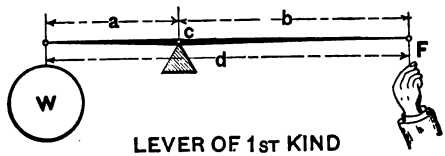
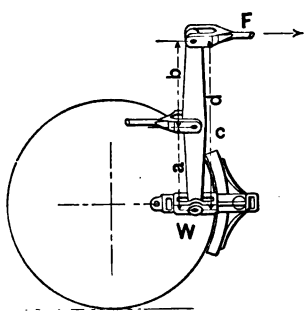


FIG. 66.



FORMULA

$W = \frac{F \times b}{a}$ $a = \frac{F \times b}{W}$

$F = \frac{W \times a}{b}$ $b = \frac{W \times a}{F}$

FIG. 67.—LEVER OF FIRST KIND.

There are three classes of levers:

I. When the fulcrum c (Figs. 66 and 67) is between the force F and the weight W.

II. When the weight W (Figs. 68 and 69) is between the force F and the fulcrum c.

III. When the force F (Figs. 70 and 71) is between the weight W and the fulcrum c.

Figs. 66 and 67 represent a lever of the first class.

Q. What brake-shoe pressure W will result with a force F = 2,000 pounds, b = 16 inches, a = 8 inches?

A. $W = \dfrac{F \times b}{a}$ or $W = \dfrac{2{,}000 \times 16}{8}$ or $W = 4{,}000$ pounds.

The forces W and F act in the same direction on the levers, and the force at c acts on the lever in an opposite direction from both and must be equal to their sum, or 6,000 pounds.

Q. What is the distance a if F = 2,000, b = 16 inches, and W = 4,000?

A. $a = \dfrac{F \times b}{W}$; substituting values,

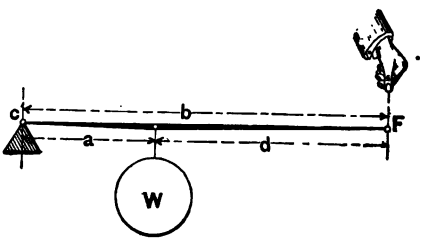
$a = \dfrac{2{,}000 \times 16}{4{,}000}$ or $a = 8$ inches.

Q. What is the force F, when W = 4,000, a = 8 inches, and b = 16 inches?

A. $F = \frac{W \times a}{b}$; substituting values,

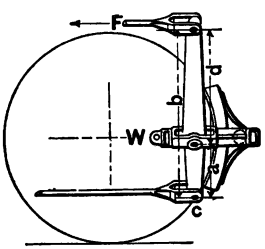
$F = \frac{4{,}000 \times 8}{16}$ or $F = 2{,}000$ pounds.

Q. How do we find b if W = 4,000 pounds, F = 2,000 pounds, and a = 8 inches?



LEVER OF 2ND KIND

FIG. 68.



$W = \frac{F \times b}{a}$ $a = \frac{F \times b}{W}$

$F = \frac{W \times a}{b}$ $b = \frac{W \times a}{F}$

FIG. 69.—LEVER OF SECOND KIND.

A. $b = \frac{W \times a}{F}$; substituting values,

$b = \frac{4{,}000 \times 8}{2{,}000}$ or $b = 16$ inches.

Figs. 68 and 69 represent levers of the second class with the weight beween the fulcrum c and the force F.

Assume that $F = 2{,}000$ pounds, $a = 8$ inches, $d = 16$ inches, and $b = a + d$, or 24 inches.

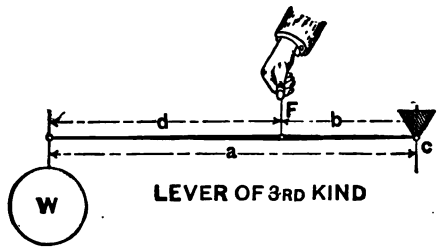


FIG. 70.

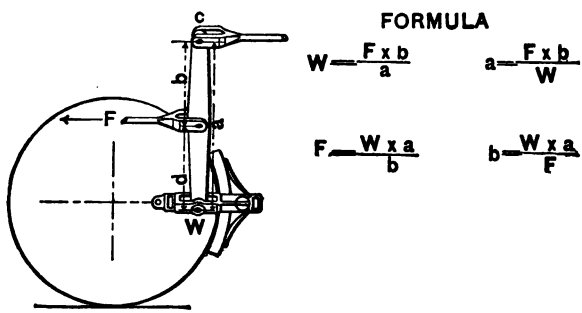


FIG. 71.—LEVER OF THIRD KIND.

Q. What is W?

A. $W = \dfrac{F \times b}{a}$; substituting values,

$W = \dfrac{2{,}000 \times 24}{8}$ or $W = 6{,}000$ pounds.

In this class of levers we see that the forces F and W act in opposite directions on the lever, and the force exerted at c will be equal to the difference between F and W, or 4,000 pounds.

We may compute values for a, F or b, as was illustrated in the first class of levers, if we know the values of the other three.

Figs. 70 and 71 represent the third class of lever with the force F exerted between the weight W and the fulcrum c.

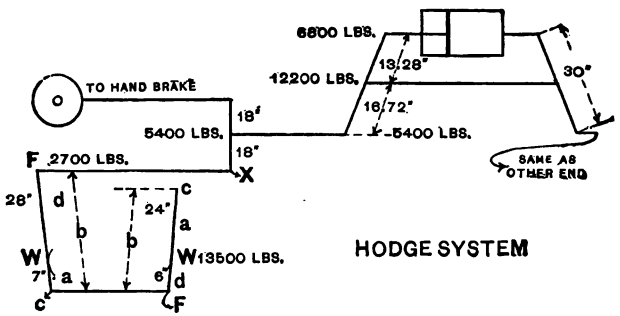


FIG. 72.

Assume that $F = 2{,}000$ pounds, $b = 8$ inches, $d = 16$ inches, $a = b + d$, or 24.

Q. What is W?

A. $W = \dfrac{F \times b}{a}$; substituting values,

$$W = \frac{2{,}000 \times 8}{24} \text{ or } W = 666\ 2\text{-}3 \text{ pounds.}$$

W and F act in opposite directions on the lever in this case, and the force exerted at the fulcrum c will

be equal to the difference between F and W, or, in this case, 1,333 1-3 pounds.

The other three formulæ may be used to find the value of a, F, or b when the other three values are known, as already shown.

Besides speaking of levers as first, second, and third class, they are known by their proportions as 1 to 1, 2 to 1, 2½ to 1, etc., according to the amount the force F is raised or diminished, due to the class and proportions of the levers employed.

To find the proportion of a lever of the first class, divide the distance of the fulcrum c to the force F by the distance from the fulcrum c to the weight W; or, referring to Fig. 66, it would be:

$b \div a$ or $16 \div 8 = 2$. This proportion of lever would be called a 2 to 1 lever.

The force F is multiplied by 2 at W.

In the second class, or Fig. 68, the proportion of the lever would be represented by: $b \div a$ or $24 \div 8 = 3$, or a 3 to 1 lever.

In the third class, or Fig. 70, the proportion of the lever would be represented by: $b \div a$ or $8 \div 24 =$ 1-3, or a 1-3 to 1 lever, in which case the proportion and class of levers *reduces* the force 3 to 1 instead of increasing it.

Having studied the classes of levers, we will now make a practical application of their use in figuring the proportion of the levers to be applied to a car of given weight.

We wish to design a brake for a passenger car, the weight of which is 60,000 pounds, and use the Hodge system of levers as shown in the sketch (Fig. 72).

Ninety per cent or nine-tenths of 60,000 pounds is 54,000 pounds. 54,000 pounds will be the safe brak-

ing power to apply to the wheels of a passenger car weighing 60,000 pounds.

54,000 ÷ 4 = 13,500, or the amount of braking power to be developed at each brake beam.

The length of the truck levers has to be determined from the truck construction. We will suppose the dimensions to be: long end, 28 inches; short end, 7 inches.

The truck levers are of the second class and substituting the values in the formula (Fig. 69)

$$F = \frac{W \times a}{b} \text{ or } F = \frac{13{,}500 \times 7}{35} \text{ or } F = 2{,}700$$

That is, to get a power W of 13,500 pounds against the brake beam, a force of 2,700 pounds is necessary at the top of the live truck lever.

The forces F and W act on the live lever in opposite directions, so the force acting at fulcrum c will be 13,500 — 2,700 = 10,800. This power is transmitted to the bottom of the dead lever, which is of the same class as the live lever; but the force F is applied at the bottom instead of the top of the lever.

We have from Fig. 69:

$$W = \frac{F \times b}{a} \text{ or } W = \frac{10{,}800 \times 30}{24} \text{ or } W = 13{,}500$$

So that, with a force of 2,700 pounds acting at the top of the live lever of the dimensions given, a power W of 13,500 pounds is developed at each truck brake beam.

The dead truck lever need not be of the same length as the live lever, but the proportions between the holes must be the same in each.

The force of 2,700 pounds that acts on the top of the live lever also acts at *X*, the end of the floating lever, and we must now determine what force must act on the rod that connects the end of the cylinder lever with the floating lever.

This rod is connected at the middle of the floating lever, and the power at this point must be sufficient to develop a force of 2,700 pounds at each end of the floating lever.

The force exerted at the middle must be $2 \times 2{,}700$ or 5,400 pounds, as half of this amount is given to each end of the floating lever.

This 5,400 pounds acting at the center of the floating lever must also act at the end of the cylinder lever, being connected directly with it.

What we now wish to determine is, with any desired length over all, how must the holes be spaced in the cylinder lever that the presssure acting on the push rod will produce a force of 5,400 pounds at the outer end of the cylinder lever.

A 12-inch cylinder is used with this weight of car. The brake set in emergency with a 12-inch cylinder gives us a push at the piston rod of 6,800 pounds, figuring the cylinder pressure developed is sixty pounds. We will suppose the distance between the outside holes of the cylinder lever to be 30 inches.

The following rule will enable us to locate the middle hole in the cylinder lever to which the tie rod is attached.

Multiply the force acting at the piston by the length of the lever between the outside holes, and divide the product by the sum of the forces acting at both ends of the cylinder lever. The result will be the distance from the middle hole of the cylinder

lever to the hole to which the connection running to the floating lever is attached.

Applying this rule to our problem we have

$$6{,}800 \times 30 = 204{,}000$$
$$6{,}800 + 5{,}400 = 12{,}200$$
$$204{,}000 \div 12{,}200 = 16.72$$
$$30 - 16.72 = 13.28$$

The distance between the holes at the short end is 13.28 and the long end 16.72 inches, and, according to the rule, the long end is connected to the connection running to the floating lever.

The force exerted at the middle hole of the cylinder lever is also communicated to a hole similarly placed in the other cylinder lever, so that, using the same levers, we will obtain the same braking power on the wheels of the other truck.

In figuring the levers for the Stevens system of leverage, the power desired at the top of the live lever is figured the same as just explained.

When we know this force, we know that the same power has to exist at the outer end of the cylinder lever, as the Stevens system has no floating lever.

This we figure by the rule already given for spacing the holes in the cylinder levers.

To figure the braking power of a car already equipped we start with the force acting on the piston rod and work toward the truck levers by the aid of the formulæ given.

To use the formulæ, first determine the class of lever with which we have to deal.

The foregoing illustrations were a practical application of the formulæ, in calculating the proportion of

levers that would give a proper braking power on a car of known weight.

We will now consider a shorter method of calculating the proportion of levers for a Hodge and for the Stevens systems of leverage for this same car.

Fig. 72 shows the Hodge system of levers. If this were a Stevens system, the floating lever would not be used, and the other end of the connection to the live lever of the truck would connect directly with the outer end of the cylinder lever. With the Stevens system the hand-brake connection runs from the brake mast direct to the top of the dead lever.

(1.) *To find the total braking power required:*

Subtract 10 per cent of the weight of the car on the wheels to be braked for passenger cars, and 30 per cent for freight cars.

(2.) *To find the leverage required:*

Divide the total braking power required by the total pressure on the piston.

(3.) *To find the proportion of the brake-beam levers:*

Divide the entire length of the lever by the short end, if the truck has a bottom connection; if it has a middle connection, divide the long by the short end.

(4.) *To find the total brake-beam leverage:*

Multiply the proportion of the brake-beam levers by two, for the Hodge system, and by four for the Stevens system.

(5.) *To find the proportion of the cylinder lever:*

Multiply the whole length of the lever by the required leverage and divide the product by the sum of the total brake-beam leverage plus the required leverage.

If the required leverage is greater than the total

brake-beam leverage, the long end of the lever must go next to the cylinder; if less, the short end goes next to the cylinder.

The dead and live levers may be of different lengths, but must be of the same proportion to develop the same braking power.

EXAMPLE.

Hodge system of levers, as shown on Fig. 72, also the lengths of the truck levers.

Weight of car, 60,000 pounds.

A 12-inch cylinder is used with this weight of car.

A pressure of 6,800 pounds is developed on a 12-inch piston by a sixty-pound cylinder pressure.

(1.) 60,000 pounds less 10 per cent is 54,000 pounds.

(2.) 54,000 pounds $\div$ 6,800 = 7.94, leverage required.

(3.) $35 \div 7 = 5$, brake-beam leverage.

(4.) $5 \times 2 = 10$, total brake-beam leverage.

Assume the length of the outside holes of the cylinder lever to be 30 inches.

(5.) $(30 \times 7.94) \div (7.94 + 10) = 13.28$ inches.
$30 - 13.28 = 16.72$ inches.

The required leverage is less than the total brake-beam leverage, hence the short end of the cylinder connects to the piston.

Stevens system—same car.

(1.) 60,000 lbs. less 10 per cent. is 54,000 lbs.

(2.) 54,000 $\div$ 6,800 = 7.94, the leverage required.

(3.) $35 \div 7 = 5$, the brake-beam leverage.

(4.) $5 \times 4 = 20$, the total brake-beam leverage.

The cylinder lever is 30 inches between outside holes.

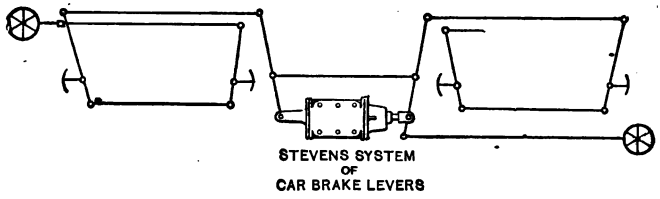


FIG. 73.

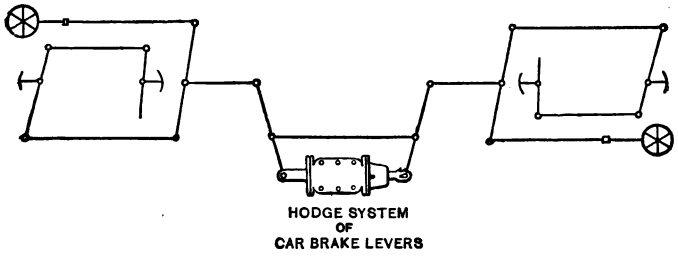


FIG. 74.

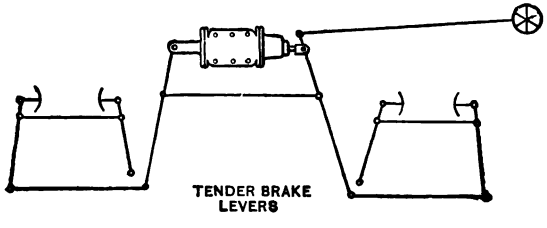


FIG. 75.

(5.) $(30 \times 7.94) \div (20 + 7.94) = 8.53$ inches.
$30 - 8.53 = 21.47$ inches.

The required leverage is less than the total brake-beam leverage, hence, according to the rule, the short end of the cylinder lever (8.53 inches) connects to the piston.

Q. Give a rule by which the braking power on practically any engine, tender or car, already equipped, may be calculated.

A. Multiply the force acting by the distance from the force to the fulcrum, and divide this product by the distance from the work to the fulcrum; the result will be the work that can be accomplished.

In this rule let F = force,
W = work,
a = distance from the point at which the force is applied to the fulcrum,
b = distance from the fulcrum to the point at which the work is to be accomplished.

Then we have the following formula which can be used:

$$W = \frac{F \times a}{b}$$

Q. What must be determined to use this rule intelligently?

A. It must always first be determined which point on any lever is the fulcrum. For instance, in considering the piston lever (Fig. 72) the fulcrum is the rod which connects the piston and cylinder levers when we wish to ascertain the amount of work that

can be done at the outer end of the piston lever. If we wish to ascertain the amount of work that can be done on the rod connecting the piston and cylinder levers, the fulcrum would then be the outer pin in the piston lever.

To find the work accomplished on the brake shoes connected to the live truck levers (Fig. 72), the lower pin of the live lever is the fulcrum; but if we wish to know what work is done on the bottom truck connection by a force acting on the top of the live lever, the point at which the brake shoe is shown represents the fulcrum.

What has been said on the subject of brake leverage in this chapter is all useful, and a thorough understanding of it will enable one to make many short cuts in leverage problems presented for consideration, but the last very simple rule will be found to be sufficient with which to calculate the braking power in practically any system of leverage.

Proper Size of Brake Cylinders for Use in Connection with Different Weights of Cars.

The weights given are those recommended by the New York Brake Company for use in connection with their equipment.

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14-inch cylinders on cars weighing from 80,000 up to 100,000 pounds on six wheel trucks.

16-inch cylinders on cars weighing from 100,000 up to 130,000 pounds with six wheel trucks.

It is very essential to use the cylinders as recommended in order not to get a total leverage that is too high, in which case the shoe clearance would be insufficient, the piston travel would increase too rapidly for a small amount of shoe wear, and a very unsatisfactory brake results.

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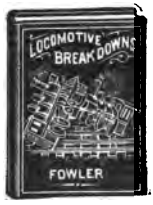

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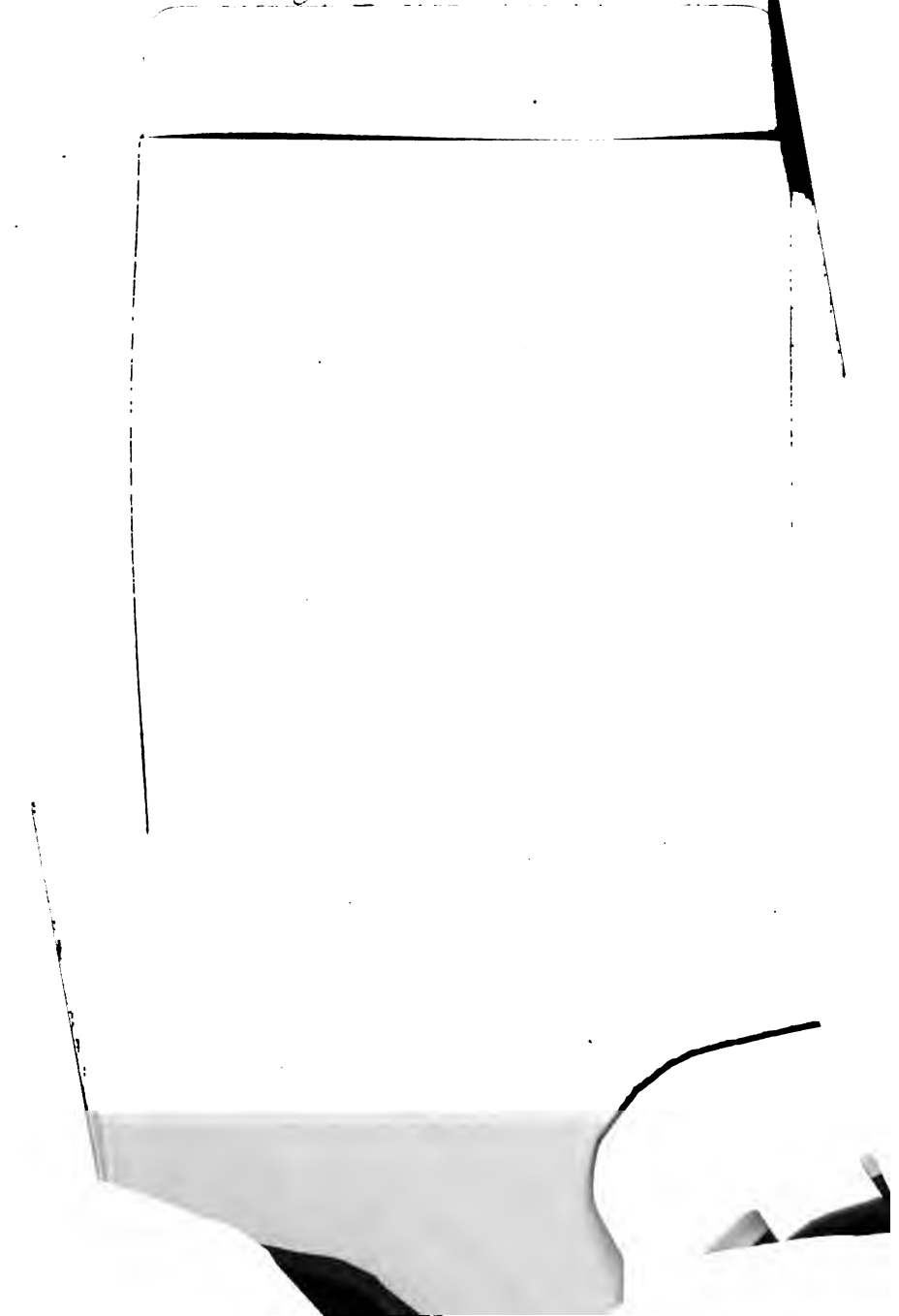

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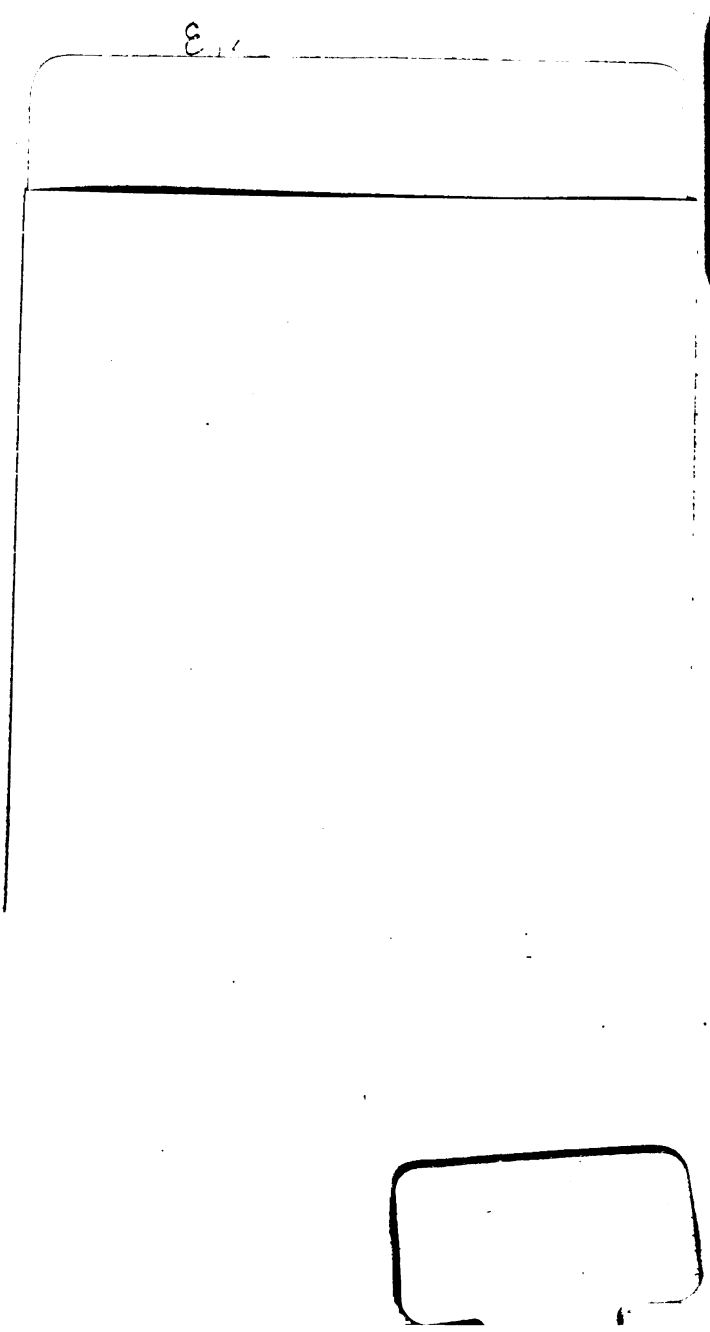
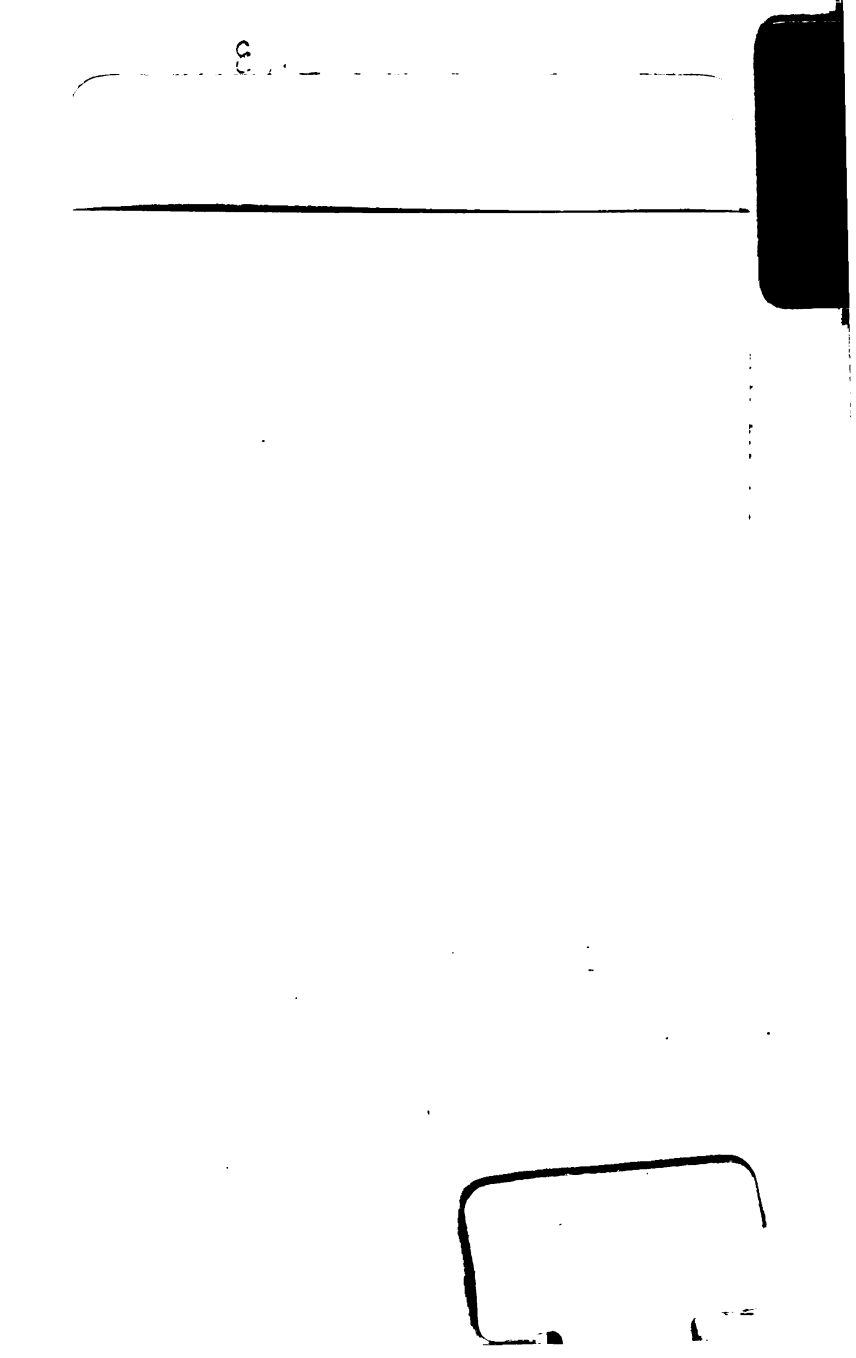
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